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PREFACE

This report represents an evaluation of the present public research program in Agriculture, Forestry and Home Economics and an estimate of future needs in this field.

The study, which began as an internal evaluation of the research program of the U. S. Department of Agriculture, involved a succession of steps, requiring for their completion some 18 months of individual and joint effort on the part of the cooperating groups who were asked to participate in the revision of the original report.

On March 15, 1956, a Committee on Research Evaluation was established within the U. S. Department of Agriculture. Its purpose and duties were defined in an Administrative Memorandum of the Agricultural Research Service, signed by B. T. Shaw, Administrator, Agricultural Research Service, and concurred in by O. V. Wells, Administrator, Agricultural Marketing Service, and R. E. McArdle, Chief, Forest Service.

The Committee consisted of the following members:

V. L. Harper, Assistant Chief for Research, Forest Service
Omer W. Herrmann, Deputy Administrator for Marketing Research and Statistics, Agricultural Marketing Service
G. E. Hilbert, Assistant Administrator, Agricultural Research Service 1/
Sherman E. Johnson, Chief Economist, Agricultural Research Service
A. H. Moseman, formerly Director, Crops Research, Agricultural Research Service 2/
Marion W. Parker, Director, Crops Research Division, Agricultural Research Service 3/
Walter M. Scott, Assistant to Administrator, Agricultural Research Service 4/
B. T. Simms, Assistant Administrator, Agricultural Research Service
Ivan H. Sims, Research Staff Assistant, Forest Service
Herman M. Southworth, Assistant to Deputy Administrator for Marketing Research and Statistics, Agricultural Marketing Service
Hazel K. Stiebeling, Director, Institute of Home Economics, Agricultural Research Service
Frederick V. Waugh, Director, Agricultural Economics Division, Agricultural Marketing Service
George W. Irving, Jr., Deputy Administrator, Utilization Research and Development, Agricultural Research Service, Chairman

The Administrative Memorandum recognized that research administrators in the Department need a comprehensive appraisal of the entire program of the

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- 1/ Left Committee, August 1956
 - 2/ Left Department, July 1956
 - 3/ Joined Committee, July 1956
 - 4/ Joined Committee, August 1956

Department--this despite the fact that the separate parts of the Federal agricultural research program are continuously and effectively examined and adjusted as the result of the judgments of research leaders and the recommendations of advisory groups. The Memorandum recognized also that there is need to consider the Department's research from the standpoint of its integration toward the overall objectives of efficiency of agriculture and improvement of incomes and living. It further recognized that special attention needs to be given to determine whether different lines of research properly complement and supplement each other, and whether changes in emphasis are needed to reach the overall objectives more effectively. The Administrative Memorandum pointed out the need to recognize in this appraisal the Department's research responsibility for maximum contribution to the problems facing agriculture in the next few years, and its responsibility to obtain research results that will be needed over the longer term.

To fulfill this purpose, the Committee was assigned the following duties: (1) To determine what our objectives should be to achieve and maintain a balanced, progressive, and prosperous agriculture for the benefit of farm people and the nation; (2) to determine what kind of a research program we should have to achieve these objectives; (3) to determine by critical and comprehensive review the extent to which current research fulfills these objectives, and (4) to recommend the specific changes required to bring the Department's research program in conformity with research objectives.

The Committee began its review and evaluation on March 26, 1956. Most members devoted approximately 80 percent of their full-time efforts to the task for a period of six months. In performing its duties, the Committee had the assistance of 20 Task Groups, each of which was assigned a specific research program area for comprehensive and detailed review. The Committee expresses its profound appreciation to the 20 chairmen and 130 members of these groups, identified in the Appendix, for the vital contribution they made to this research evaluation effort.

Throughout its evaluation of the Department's program, the Committee was impressed by the fact that the research programs of the Department are, in the great majority of instances, directed toward problems that are timely and important and that they effectively complement and supplement each other. Projects are scrutinized carefully by research directors and their staffs before initiation, and funds are shifted promptly as aspects are solved or abandoned and efforts are redirected to other phases of problems awaiting attention. The substantial turnover of line projects recorded in the Central Project Office is evidence of the dynamic nature of the Department's research program. The Committee has recommended some program curtailments, but these constitute a vanishingly small proportion of the total program and probably represent no more than would be expected to be due for change at any moment of inspection in a research program as large as the Department's.

The Committee's report was submitted on October 10, 1956. Copies were made available to the Federal-States Relations subcommittee of the Experiment Stations Committee on Policy prior to the November 12-15, 1956 70th Annual Convention American Association of Land-Grant Colleges and State Universities

and, following discussions at that meeting, agreement was reached that the report could and should be made to reflect not only Federal thinking with respect to the present and future of agricultural research but thinking at the State level as well. The Department's Agricultural Research Policy Committee also reviewed the report at this time, concurred in the broad recommendations, suggested minor revisions, and agreed that collaboration with State program people in developing a joint report would be desirable. Accordingly, a subcommittee representing the State Agricultural Experiment Stations, a subcommittee representing Forestry Schools, began detailed study of the Department's report late in 1956.

Members of the State Agricultural Experiment Stations Review Subcommittee were:

Floyd Andre, Director, Agricultural Experiment Station, Ames, Iowa
 J. M. Kraus, Director, Agricultural Experiment Station, Moscow, Idaho
 J. H. Longwell, Director, Agricultural Experiment Station, Columbia, Missouri
 E. V. Smith, Director, Agricultural Experiment Station, Auburn, Alabama
 C. W. Upp, Director, Agricultural Experiment Station, Baton Rouge, Louisiana
 H. R. Varney, Director, Agricultural Experiment Station, Morgantown, West Virginia
 W. B. Young, Director, Agricultural Experiment Station, Storrs, Connecticut

Members of the Forestry Schools Review Subcommittee were:

George A. Garratt, Dean, School of Forestry, Yale University, New Haven, Conn.
 Frank H. Kaufert, Director, School of Forestry, University of Minnesota, St. Paul, Minnesota
 Walter F. McCulloch, Dean, School of Forestry, Oregon State College, Corvallis, Oregon
 R. J. Preston, Director, Department of Forestry, North Carolina State College, Raleigh, North Carolina
 Hardy L. Shirley, Dean, College of Forestry, State University of New York, Syracuse, New York
 Henry Vaux, Dean, School of Forestry, University of California, Berkeley, California
 R. H. Westveld, Chairman, Department of Forestry, College of Agriculture, University of Missouri, Columbia, Missouri

The review subcommittee of the Committee on Research Evaluation was composed of: V. L. Harper, S. E. Johnson, M. W. Parker, H. M. Southworth, H. K. Stiebeling and G. W. Irving, Jr.

E. C. Elting, Deputy Administrator for Experiment Stations, Agricultural Research Service, was chairman of the subcommittees.

joint

A draft of the report, dated May 1957, is being submitted for critical review to personnel of the U. S. Department of Agriculture, the Agricultural Experiment Stations, Departments of Forestry and of Home Economics, and the National Farm Organizations. A final report will be compiled after further study of the suggestions made by these groups.

The report is organized in five parts, as indicated in the Table of Contents. Part I of the report states sixteen objectives which must be successfully sought through research if we are to achieve and maintain a balanced, progressive, and prosperous agriculture for the benefit of farm people and the nation. Part II states the basic considerations in terms of which the Subcommittee examined the country's agricultural research program and arrived at the broad program conclusions and recommendations presented in Part III. Part IV projects the needs for a balanced, effective agricultural program in public institutions and Part V presents some factors affecting the achievement of research expansion goals.

The report is intended to reflect the views of those most concerned with publicly supported research in agriculture in the United States.

I. Objectives for Agricultural Research

This study is concerned with the contribution of research towards attaining and maintaining a balanced, progressive, and prosperous agriculture for the benefit of farm people and the Nation. It includes research in forestry and home economics. It considers research relating to the production of farm and forest products, the processing and distribution of these products, the provision of materials, facilities, credit, and other requisites for these activities, and research relating to services to farm families, to rural communities, and to the general public. Although the study is concerned primarily with publicly supported research, it takes into account that much research on problems relating to agriculture is conducted by endowed research institutions and by private agencies.

Prerequisite to intelligent evaluation of the contribution of research is the delineation of the conditions that must be fulfilled if a balanced, progressive and prosperous agriculture is to be achieved--the delineation of the framework within which the research program must operate.

The Nation is dependent on an adequate, efficient, and economical supply of farm and forest products. It depends upon agriculture to make special provision for needs of national defense in terms of strategic commodities and reserve productive capacity against emergency. It expects agriculture to balance its production in relation to current market demands, and anticipate and adapt to changing needs that will result from population increase, foreign trade conditions, new uses for farm and forest products, development of competitive products, dietary improvements, and other advances in levels of living. It expects agriculture to be progressive, striving constantly to improve its efficiency at a rate comparable to the progress in productivity of the industrial economy. And it expects agriculture to manage its resources so as to safeguard our ability to meet the needs of future generations for food, fiber, and forest products, and to meet the continuing needs for watershed protection, wildlife habitat, and forest recreation.

Agriculture expects in return that if it fulfills these responsibilities, it will be enabled to share fully with the rest of the economy in the rising levels of living that progress makes possible.

Obviously, agriculture cannot meet these responsibilities -- nor share in these benefits -- operating alone. For efficient production and technological progress, agriculture depends upon an increasing variety of industries that furnish machinery and facilities, and supplies of petroleum products, fertilizers, insecticides, and the other goods and services needed for modern farm production. In fulfilling its task, agriculture also depends upon efficiency and progress in the related industries that process and market the end products made from the raw materials from farm and forest. Finally, to realize the potential of its contribution to the Nation's rising levels of living through new and improved products and their wider distribution, agriculture depends upon a public well informed of the relative economy and usefulness of its products for satisfying human needs and wants.

It is apparent, therefore, that achieving and maintaining a balanced, progressive, and prosperous agriculture is a complex and difficult undertaking which requires continuing contributions of nearly all segments of the economy from the farm and factory to the laboratory and the consumer, and from efforts nurtured by private funds to those supported by public appropriations both State and Federal. Research contributes directly to agriculture's welfare, and it also provides a necessary foundation for many other contributors. To function most effectively, research should seek to attain the following objectives:

1. To increase knowledge regarding the needs, wants, and preferences of people for agricultural and competitive products, and to develop means of applying this knowledge in educational and other programs relating to production, processing, marketing, and consumption.
2. To discover, identify, and measure the inherent nutritive and other values of farm and forest products that make them useful in satisfying human needs and wants directly as food, textiles, or other products, and indirectly, through industrial processing; and to develop handbooks, tables of values, or other guides for selecting and using these products effectively.
3. To appraise periodically the prospective demands for the many farm and forest products and the current and potential capacity for production, processing, and distribution of these products to meet short and longer term market demands and to determine the balance between supplies and market demands for each commodity and in total for farm and forest products; also to determine the adjustments in production, processing, and distribution (including the development of domestic and foreign outlets) that are necessary to achieve a desirable balance between supplies and market demands in the years immediately ahead and over the longer term.
4. To identify the obstacles to achievement of balance between supplies and market demands for different products, to provide technical and economic guides in overcoming these obstacles, including analysis of credit and other program assistance needed to accomplish adjustments that are profitable to producers and in the public interest.
5. To undertake the research needed for improvement of buildings, facilities, and equipment used in production, processing, and marketing, and to insure their availability for efficient use.
6. To develop those practices in the use and management of agriculture's basic resources of soil, water, forest and range, and germplasm of plants and animals that will conserve and improve their capacity to provide needed goods and services.
7. To increase knowledge of diseases, pests, and other hazards that affect the production and marketing of crops, livestock, and timber, and their products; to develop practical methods of controlling, preventing, or reducing losses therefrom; and to provide a research basis for minimizing the effects of these losses through insurance or other measures.

8. To be cognizant of national needs in times of emergency, and to develop the research necessary to provide supplies of, or substitutes for, strategic and critical agricultural materials, and for the supply and effective use of other needed farm and forest products, at levels required by the emergency.
9. To increase efficiency in the production, processing, and marketing of farm and forest products by reducing loss and waste and by developing technological and managerial improvements.
10. To identify, maintain, and enhance the quality of farm and forest products through development of improved production, processing, grading, marketing, and household practices.
11. To develop profitable, new and improved uses and market outlets for farm and forest products, and profitable new crops and types of livestock.
12. To study means of motivating desires for higher levels of family living, and to provide technical and economic guides for improved management and use of family and community resources, including those for health, education, housing, and such other goods and services as may be involved.
13. To analyze the comparative advantages and disadvantages to farmers and to the Nation of alternative types of organization of farming so as to provide guides for improvement of the income of the farm family over the long term.
14. To appraise the various forms of organization and operation of markets for farm and forest products, and of policies and practices in the conduct of trade in such markets, including farmers' marketing, purchasing, and service cooperatives; and, if possible, to develop improved methods of organization and operation.
15. To provide comprehensive and reliable statistics on matters basic to agriculture, including statistics on production, prices, farm income, utilization, consumption, and trade.
16. To determine the effects of broad agricultural policies and programs, and explore alternative policies and programs, designed to improve the income of farm people and strengthen both agriculture and the economy as a whole; to determine the interrelationships and to further mutual understanding of interdependence between agriculture and other segments of the economy.

II. Basic Considerations

In the light of these objectives the task is one of determining specifically in what ways publicly supported research should contribute to the attainment of these objectives and what changes are needed in the present program to make this contribution adequate in the years immediately ahead and over the longer term.

In approaching this task it was necessary to establish a framework of basic premises against which the present publicly supported research program in agriculture would be evaluated and suggestions made for projection of future research needs.

These basic considerations are presented in this section. They indicate under "Importance of Research to Agriculture and the Nation" the increasing importance of agricultural research in our complex society; under "Outlook for Agriculture;" the prospective balance between demand and productivity; under "Continuity and Emphasis in Research," that research should go forward on broad fronts, and that additional emphasis is needed on problems of economic adjustment; under "The Responsibility of Publicly Supported Agricultural Research Institutions," that these institutions have an important and inescapable responsibility for pursuing a vigorous research program; under "Size of the Agricultural Research Program," that agricultural research throughout the country should be expanded by about $3\frac{1}{2}$ times to cope with the problems before us.

Importance of Research to Agriculture and the Nation

Viewed in historical perspective, both farm people and the Nation as a whole have benefited greatly from technological advances in agriculture. Real income (purchasing power) per farmworker has doubled in the United States since the beginning of World War I. The physical burden of farmwork has been lightened both on the farm and in the farm home. More money has been available for home and community improvements. Young people on farms today receive a better education and are better equipped to participate in both the private and the public activities of our complex civilization.

At the same time, technological advances in agriculture have released labor for the production of nonfarm goods and services. Whereas in 1910 one farmworker produced food enough for only about 7 persons, in 1955 one worker produced enough for about 20 persons. Our urban industrial economy, with its high standard of living, could never have come into being except for the development of our efficient, highly technological, specialized system of production of basic agricultural necessities -- food, fiber, and forest products -- and the efficient far-flung system of marketing through which farm products are assembled, transported, processed, stored, and distributed.

Meanwhile, farm people have enjoyed great benefits from technological progress in industry, both in terms of machinery and equipment to lighten their labor, and in terms of their enjoyment of automobiles, electric power, and other essentials of modern living. Technological advance in agriculture and technological advance in industry are mutually interdependent; they have worked jointly to make possible our present high levels of living for farm and city people alike.

Technological advances, whether in agriculture or industry, do not come about spontaneously. Increasingly they have their origin in public or private research. Particularly in the case of agriculture, we have developed a publicly supported system of institutions for the conduct of research, for the wide dissemination of its results among the farming population, and for the education and training of farm people in the managerial and technical skills that are required to take advantage of the new opportunities. These institutions, and the benefits they have brought, are the object of worldwide admiration and emulation.

But the counterpart of technological advance has been that farming has become more complex. It requires greater managerial and technical skills. More money is needed to get started in it, and the farm business has become more vulnerable to the ups and downs of the market and to production hazards. The adoption of technological advances, made possible through research, thus gives rise to problems to which research must give attention. Less advanced societies maintain a relatively stable existence at a low level of subsistence. We have chosen the more risky path of progressively higher levels of consumption based on an intricately inter-related, highly organized system of production whose maintenance and development require our constant attention.

While the foregoing applies generally, especially to farming and farm products, it must be noted that in forestry many of the basic conditions that characterize its present situation are far removed from those of the rest of agriculture. In forestry, technological advance on the average has been slow and the organization of production and marketing is quite different. Some 34 percent of the timber-producing land is held by farmers, and another 27 percent is in small ownerships of non-farmers; characteristically these lands support the poorer crops of market-surplus hardwoods. The remaining 40 percent of timber-producing land is in much larger holdings, 13 percent industrial, and 27 percent in national forests and other public ownership. Here are found the tightening supplies of preferred softwoods, and here, particularly in the public holdings, the production of timber products is becoming increasingly complicated by the need to harmonize it with the growing requirements of forest recreation, wildlife habitat, grazing, watershed protection and water yield. These differences between the basic problems of forestry and those of the rest of agriculture are indicative of those that bear significantly on the relative importance of various lines of research and on the distribution of the research load among the several agencies concerned.

A good research program, consequently, must recognize these and other differences and above all must be forward looking. It must be aware of the needs for new and more efficient technology and it must be aware of the processes that research has already generated. It must anticipate future problems, and must devise ways to solve them before they become critical.

Outlook for Agriculture

In evaluating our agricultural research program it is, therefore, essential to examine the situation in which agriculture stands today, to appraise the problems confronting it now and in the foreseeable future, and to determine the needed balance and emphasis of research in the light of these problems.

Most technological advances in farm production are associated with larger output of the product involved. When the market is expanding rapidly, as during the war and rehabilitation years, the increased output is absorbed without a reduction in farm prices. The general economy benefits because the larger output retards a rise in consumer prices. Under those conditions farmers retain most of the direct gains from adoption of new technology.

But when market demand slackens, or expands less rapidly than output, production-increasing improvements are likely to result in lower prices for the products involved. When that happens, a part or all of the gain may be shifted away from producers to the benefit of other groups. Progress ceases to spell prosperity for farmers.

What is the current and prospective status of this balance between demand and productivity? The market will doubtless continue to expand as our country grows and prospers. For example, statisticians estimate that by 1975 the population of the United States may be 30 percent higher than in 1953, and that per capita real income may be 60 percent higher. These projections assume world peace and an expanding economy. Under them, total consumption of farm and forest products might increase by 40 to 45 percent.^{1/} Assuming a continuation of past trends in per capita consumption, there would be substantial increases in the domestic markets for livestock products, fruits and vegetables, and

(continued on page 6)

^{1/} Rex F. Daly. The long run demand for farm products. Agricultural Economics Research, July 1956.

Glen T. Barton and Robert O. Rogers. Farm Output: Past changes and projected needs. U. S. Dept. of Agr., Agr. Inf. Bul. No. 162, August 1956.

James C. Rettie. Future domestic requirements for timber. Chapter VI of Timber Resource Review, U. S. Forest Service. September 1955.

forest products. There would be less expansion in markets for cereal products, potatoes, and dry beans. A more widespread understanding by the public of the essentials of human nutrition may, however, modify the rate of change in consumption of some commodities.

While it is always difficult to foresee the distant future, present indications point to further expansion in agricultural markets well beyond 1975. Consequently, a hasty look at the estimates of future needs might give the impression that the future problems of agriculture are few and simple -- perhaps, mainly how to increase the output of livestock products. Such an impression would be quite misleading, however.

With the continued adoption of modern technology, the output of American farms could easily increase faster than potential markets during the next decade. Further improvements in technology are essential to the long-time prosperity of agriculture and the Nation. But agriculture is peculiarly susceptible to painful maladjustments associated with such progress. If farmers are to share in the expected prosperity of the Nation, research must find ways to overcome these maladjustments. While agricultural output must be kept in line with demand, every effort must be exerted to increase the market for farm and forest products. Costs of production and marketing must be minimized by the general adoption of the most efficient methods. New market outlets must be developed. Low-income farmers must be helped either to get a better income from farming or to find profitable nonfarm opportunities. Government programs must be made more effective.

The increases in demand for timber and other goods and services from forests will inevitably result in a growing number of critical problems. Quality timber of preferred softwood species is likely to be in particularly short supply. On the other hand there are substantial surpluses of little-used and low-grade hardwood trees occupying extensive areas of farm and other forest holdings at the expense of productive timber stands. Increases in demand for water are occurring now, and they will continue to mount. To meet this demand, water will require protected and properly managed watersheds in forested areas. Demands for outdoor recreation, for better wildlife habitats, and for the production of livestock and game from forest and related rangelands also continue to increase. The lack of balance between timber supplies and potential demands, along with the various other and frequently competing uses, will require many adjustments as well as greater efficiency in forest production, and in the utilization and marketing of forest products.

Serious maladjustments have occurred in agriculture after every great war. After World War II many of these adjustments were postponed because of the need for supplying food to other countries and because of the Korean outbreak in 1950. By now it is clear, however, that adjustments must be made in farm production and in the use and marketing of farm products. Needed adjustments must be made promptly if agriculture is to be prosperous and if it is to contribute effectively to the prosperity of the Country.

The farmer faces a serious economic situation right now. His income fell each year from 1951 through 1955, in spite of new heights of prosperity in the non-agricultural sectors of the economy. His production expenses have stayed high. Costs of processing and marketing farm products have continued to rise.

Despite unfavorable cost-price relationships, farm output has continued at record levels and seems likely to remain high. Assuming no international crises that raise demand, nor widespread crop failure to reduce output, the farmer may continue for several years to be burdened with surpluses and with downward pressure on prices of his products. High costs of production and marketing are likely to persist.

Continuity and Emphasis in Research

In the light of the outlook just presented, the agricultural research program should give greater emphasis to helping solve problems of economic adjustment. One approach is the expansion of markets for farm and forest products. This can take place by: (1) Increasing direct domestic consumption, (2) developing new uses, and (3) expanding exports. Increasing direct domestic consumption (beyond the increase that comes with population growth) requires chiefly improved diets with respect to nutrition of underconsuming groups, shifting consumption from lower value to higher value products. When people eat more livestock products instead of staple food crops, for example, more land and other resources are used to produce feed and livestock; and consumption of more livestock products in turn results in larger farm income and greater consumer satisfaction. To expand industrial uses it is necessary not only to ascertain physical suitability and consumer acceptability, but also to determine whether the products made from agricultural raw materials can be sold at prices that compete with products from nonagricultural sources. New uses for farm and forest products must be explored to the fullest extent, and only agricultural agencies interested in expanding outlets for these products can be relied upon to analyze their potentialities as sources of industrial raw materials. Expansion of export markets encounters many difficulties, including competition from other exporting countries and purchasing power limitations of importing countries. Research, therefore, is needed to determine the potentialities of foreign outlets and to seek out ways of increasing export markets.

What should be our policy, in the current situation, regarding research that may lead to increased production? In deciding the emphasis to be given such research, the following considerations should be kept in mind:

- (1) Much "production increasing" research is a part of the research needed to protect the gains already made. For example, research on diseases and pests of livestock and plants, and conservation of forest, soil, and water resources.
- (2) Agriculture must keep in step with both technical and economic progress in the rest of the economy in order to provide income opportunities that will attract and retain persons of ability in farm occupations. The alternative may be a static, peasant type of agriculture.
- (3) Technological advances are necessary to compete effectively in world markets, and with nonagricultural products in domestic markets.

- (4) Improvements that lower costs are profitable to farmers who first adopt them and, even if all or part of the gain later is shifted to other groups through a decline in prices, more efficient production benefits the general economy. But research also should develop ways by which farmers can continue to share in the gains from technology.
- (5) Research is time-consuming; it cannot be turned on and off like water from a faucet. Basic research must be undertaken now to provide information for adequate production of food and fiber at low cost in future years.
- (6) The margin between scarcity and abundance is relatively narrow, and research "know how" should be a part of our reserve capacity to meet emergencies such as severe drought or international crises.

These considerations lead to the conclusion that research should go forward on broad fronts, and that the results should be used whenever adoption becomes advantageous. But because the benefits of technical advances in agriculture often tend to be shifted to other groups, the national interest requires that the research program place strong emphasis on improving incomes of those who encounter substantial hardship as a result of technical and other changes that are beyond their control as prudent individuals. In other words, research should attempt to reconcile the apparent current conflict between progress and prosperity for agriculture. This will require greatly expanded economic research to help guide production into lines that promise higher incomes to farmers; research designed to remove financial, tenure, and other obstacles to needed adjustments; research to find ways to cushion the shock and improve incomes for those who are seriously disadvantaged by changes; and research to appraise the changes in the organization of agriculture that are likely to emerge.

Public recognition of the need for cushioning the impact of price declines that are caused not only by technical advances but more importantly by changes in domestic and export markets has resulted in development of programs to support prices and to facilitate production adjustment. For most effective operation of such programs, research is needed to provide facts concerning the situation to be dealt with, to analyze the probable results from alternative programs being considered, and to examine critically the effects of programs in operation. Research along these lines is also needed to aid effective operation of programs such as soil conservation, management of national forests, watershed protection, crop insurance, credit, and the regulatory and service programs.

A bold program of agricultural progress in the interests of farmers and the Nation as a whole requires a strong underpinning of research to attack all major problems relating to agriculture and the welfare of farm people. Moreover, to guide an aggressive research program along sound lines, more attention should be given to anticipating future trends and developments likely to affect agriculture, and to analyzing their prospective impacts, the problems they will create, and the opportunities they will present.

The Responsibility of Publicly Supported Agricultural Research Institutions

The Department of Agriculture, the State agricultural experiment stations, and certain other public institutions are charged with acquiring and disseminating information on problems confronting agriculture in its broadest aspects. These institutions thus have a real responsibility for research on all agricultural problems whether local, State, national, or international and, therefore, have a mutual interest in their solution. The Department shares with the State experiment stations responsibility for conducting federally supported research on agricultural problems. Furthermore, each State experiment station is supported to a large extent by funds of State origin. Also, certain other State agencies, notably some State Colleges of Forestry and Colleges of Veterinary Science, outside the framework of the experiment stations, receive appropriations for research in their respective areas.

To be fully effective, a research effort so widely dispersed must be coordinated. The Department of Agriculture is in a favorable position to work with its cooperators on the coordination of the overall program to

bring about a balanced nationwide attack on all problems important to agriculture. Furthermore, there are many mechanisms operating at the State level, particularly the planning and conduct of cooperative regional research involving groups of States having mutual interest in such projects which contribute to effective research coordination.

It is recognized that in many fields of research, responsibility cannot be exclusively assigned either to the Department or to the State experiment stations. In these fields, responsibility must be shared. It is always advisable, however, to determine whether major responsibility is to be Federal or State, and the determination can usually be made on the basis of the extent of the geographical area that is, or that may become, affected. While the Department naturally concerns itself with those problems that are of broad regional or national significance, and while the States are particularly adapted to dealing with problems of a local nature, these areas are by no means mutually exclusive. Much of the research in which Department scientists participate finds local application as well as having regional or national significance. On the other hand, much of the research accomplished by State experiment station scientists finds wide application. The important consideration is that, within the limit of existing support, cooperative planning procedures insure a broad and, so far as possible, adequate coverage of the wide range of problems confronting agriculture.

There is another broad field in which the Department and the States are obliged to maintain close cooperation. Private industry has become more interested in agricultural research because of the increasing use of machinery, fertilizers, and pesticides. The public agencies have the responsibility of maintaining close contact with these private agencies, especially in informing them of agricultural problems that are of broad significance. How industry assists in the research depends on the nature of the problem. Scientists in industry frequently wish to participate in the research. Also, industrial organizations frequently provide additional support for research in the public agencies. Private industry does most of the research on the synthesis and production of agricultural chemicals and biologicals. The Department and State stations cooperate on extensive biological testing of these materials. Likewise, private industry does extensive research and development work on farm machinery, while the Department and State agencies do research on basic engineering principles used in new machines, on refinement of existing equipment, and on development of equipment for special purposes.

Even if industry does not wish to participate in the research, it may offer information of value to publicly supported research scientists. As an example, insect attractants are specific, and most companies are not interested in undertaking research on the subject. However, as leads develop in the Department or State stations, industry may find useful related chemicals.

In determining whether to undertake research in specific problem areas, publicly supported research agencies must consider the potential long-range benefits to agriculture and to the Nation. Productive research upsets the status quo, and may be resisted by groups adversely affected. It develops

new ideas, facts, techniques, or products; these may impinge on the established order and cause revolutionary changes; they may bring financial hardship to persons who are producing the outmoded commodities, or using the obsolete techniques. It seems clear that the Department and States cannot adopt a policy of avoiding performance of research because some segments of agriculture may, at the time, object.

When gas engines began to replace horses and mules, a strong national organization was set up to promote the use of draft work stock. Some milkers on dairy farms actively opposed the use of milking machines. At least a few beef producers in the range States have become alarmed because research is developing better pastures in the Southeast which are being used to produce beef. These are a few instances of opposition to innovations of the past. There would be many more such instances in the future if public agencies adopted the policy of avoiding "controversial" research. Examples: Corn producers might object to work with grain sorghum, which competes with corn; cotton growers might protest against soybean research, because soybean oil competes with cottonseed oil; orchardists in the Western States might request that research on pear blight be halted, because control of the disease would remove an obstacle to pear growing in other regions.

The Committees consider it reasonable that the decision to do research in any field in which agriculture has responsibility be made on the merits of each case. The long-run potential benefits to agriculture and to the Nation should be the determining factor. There can be no reasonable doubt that this policy will be to the advantage of both agriculture and the general public. But when and if it becomes apparent that the result of research under way is likely to cause serious and sustained hardships to any considerable segment of agriculture, the Department and State stations should immediately assume leadership in developing means to prevent or alleviate the harmful effects. This may often require both research and action agency participation.

Size of the Agricultural Research Program

Research in agriculture is concerned with many of the goods most essential in sustaining human life--food, clothing, wood building materials, paper for communication of ideas, and transportation of materials. Assurance of adequate supply of these necessities, at reasonable cost to consumers, and in products suitable to meet their needs, is a prime requisite for national strength and well-being. Moreover, the people who supply these materials should have their fair share of the Nation's income for services rendered. These objectives can be attained only if technology in agriculture keeps pace with technology elsewhere in the economy.

No one would seriously advocate that technology in agriculture should not keep pace with technology elsewhere. Yet it may not be so clear that to keep pace presupposes an expanded program of research, a program large enough to include the whole complex of problems facing agriculture, a program that would seek a balanced result calculated to serve better both the producer and the consumer. It should be an aggressive effort to reduce wastes and

losses; to improve efficiency of production, processing, and distribution; to develop new and improved crops and products; to expand markets; and to provide improved nutrition and better living for rural and urban people. And, moreover, it should do these things in a way that will conserve and improve the Nation's basic natural resources of soil, water, forests, and ranges.

Research effort so far devoted to agriculture has been too limited to meet these standards. The principal reason is insufficient size. The Federal, State, and private expenditures for agricultural research are currently about \$335 million annually. This sum is little more than 0.3 percent of consumer expenditures for farm and forest products. In contrast are the much bigger research expenditures of other parts of the economy. Many progressive industries spend as much as 3 percent of their gross income on applied and basic research and some expend even a higher proportion. The National Science Foundation has estimated that the 1953 expenditures for all research in the United States amounted to about \$5 billion or approximately 1.3 percent of gross national production. To be at par with the national average of research effort in all fields, programs in agriculture would have to be much larger than at present.

Consumer expenditures for farm products currently are about \$75 billion annually and those for forest products are about \$25 billion. In addition, it must be realized that there are problems in agriculture and forestry that require attention whether or not they are measurable in market values. Conservation of soil, water, and of forest recreation values is in this category. Using only consumer expenditures of \$100 billion as base, a research program for agriculture of about \$1.3 billion would not be excessive or out of reason. This amount would be on par with the rest of the economy at least insofar as market values are concerned. The amount appears to be more than justified considering the importance of agriculture in the economy, the gravity and complexity of agricultural problems, and the pace at which technology in the rest of the economy is advancing.

Practical considerations, however, such as the scarcity of technically trained personnel and the time required to expand research facilities effectively, would indicate a somewhat less ambitious goal for agricultural research for the immediate future. A reasonable objective would be to steadily raise expenditures of Federal, State, and private agencies from the current level of \$335 million per year to about \$1.2 billion per year to be reached at the end of the next 10 years and to be about equally divided between public and private institutions. This would mean expanding present expenditures 3-1/2 times by fiscal year 1968 so that an annual public research expenditure level of approximately \$600 million would be achieved by that time.

With the momentum thus gained in reaching a goal of about \$1.2 billion per annum over the next 10 years, it should then be possible to sustain the expansion of Federal, State, and private programs until they measure up to the full importance of the problems facing agriculture and until research effort in agriculture reaches parity with research effort in other fields of investigation.

III. PROGRAM CONCLUSIONS AND RECOMMENDATIONS

Objective 1.--Consumer Needs, Wants, and Preferences

Research Program Needed

The Nation depends on agriculture to supply the food, fiber, wood and tobacco wanted by consumers for reasons of health, safety, comfort, convenience, and other human satisfactions. To serve the needs of consumers and to point the way of profitable adjustments in agriculture, research is needed to determine the kinds and to define the quantities of the various agricultural products that people need and want, and to delineate the factors influencing demand. Needs and wants of consumers involve both physiological requirements and tastes or preferences that are conditioned by social environment.

The U. S. Department of Agriculture and the States have long accepted responsibility for research into the nutritional needs of healthy, normal people. Well before the end of the 19th century agricultural scientists recognized from study of animal nutrition that diet can affect health and vitality at every period of life. Accordingly, they undertook and have continued research in human nutrition, both as a contribution to human welfare and as a necessary guide to agricultural programs. As a basis for guiding production, distribution and effective consumer use of food, there is a primary need for systematic knowledge on this subject.

Knowledge of the nutritional importance of the components of food is only the first step in understanding the needs of the human body. The degree of need differs for children, youth, young adults, and older people, and with circumstances. Information on these points is important both to health and agriculture, because under the influence of the developing science of nutrition, new concepts of food needs emerge. Such knowledge is gradually reflected in food habits and market demand. For example, through facts on human requirements for amino acids, calcium, and riboflavin, nutritional knowledge has provided a basis for recommending increased consumption of milk, and, through facts on vitamin C requirements, a basis for the increased consumption of citrus fruit. As a result of such new knowledge, together with technological developments affecting quality, price, and convenience, a marked increase in market demand for these products has taken place over the last quarter century to the benefit of agriculture and health.

Research into physiological needs for food should include studies of the quantities and proportions of all nutritive substances required by the human being to yield energy, to build or renew body tissues, and to regulate body processes. This involves research into the requirements for nutrients; into the functions and interrelations among food constituents, both useful and harmful; and into the normal variability in bodily response of individuals to various types of food and diets, and factors affecting such responses. It also involves research to translate nutritional knowledge into practical terms for application in educational and other programs, such as food distribution, rural development, social welfare, and disaster relief.

There has been growing appreciation of the potentialities of research into physiological needs for food to guide related long-term programs of agriculture, health, and education. However, little has yet been done to investigate the relationships to human well-being of properties of other agricultural products, such as clothing, house furnishings, paper products, and detergents. Undoubtedly the benefits of such research to agriculture and health would be very considerable, and research should be undertaken to explore and cultivate this entire field.

Socially conditioned wants and preferences for food and other goods and services are reflected in the quantities of different kinds of items purchased, and in consumer attitudes toward, or preferences among, different forms or qualities of goods that serve various end-uses. The products selected and used by consumers to satisfy their needs and wants are influenced by many economic and social factors, including people's ideas about food in relation to health and what is socially acceptable in food, clothing, and housing.

Agricultural research programs should include investigations into practices in the consumption and use of the many kinds and forms of agricultural and competitive products and consumer attitudes toward them. Such information is needed in terms of national averages and also for segments of the population classified by region, degree of urbanization, income, age, occupation, educational level, and such other characteristics as may affect consumption levels or influence choices. Especially needed to show dietary patterns and dietary adequacy is information on the division of food supplies among family members, the contribution to diets of food eaten away from home, the extent to which diets vary with season, and the deductions to be made from food supply estimates for discard or waste of food in the home. At present, there appears to be a gap of 20 to 30 percent in calorie value between food estimated as entering the Nation's kitchens and that estimated as actually eaten. Knowledge of the nature and quantity of foods that contribute to this "loss" is essential to diet appraisal and to understanding of market supplies needed to support any given consumption level.

Analyses of data on consumption and attitudes of various population groups towards various products at a given time under differing economic situations and trends over time, reveal the relative importance of various economic and social factors in influencing the intensity of needs and wants for different goods. Comparison of the nutritive content of diets of various population groups with research-based standards for dietary adequacy provides a basis beyond gross physical hunger for locating "underconsuming" groups whose diets need improvement. Such researches on needs and wants contribute facts essential for forecasting market demand, and form the background for developing realistic educational, marketing, food distribution, and other programs designed to modify consumption for the improvement of health or general well-being.

Recommended Changes in the Present Program

Present research programs basic to understanding the needs and preferences of people for agricultural and competitive products are singularly inadequate. Research on physiological needs should be vastly increased. The current program on food needs is weak both in scope and in depth; that on physiological aspects of needs for other goods is virtually non-existent. Research to delineate present consumption patterns and to understand the factors affecting them also needs much strengthening, especially through information obtained directly from consuming units. The implications of such data both for agriculture and for the welfare of the public should be analyzed.

To provide a better balanced and expanded research program on physiological needs for food, research should be expanded and accelerated on physiological requirements for the many essential nutrients by different age and sex and activity groups under varying environmental conditions; on interrelations among nutrients, such as those among amino acids, among different fatty acids, amino acids, and vitamins; and among "trace" minerals. Also expanded should be studies to determine bodily response to various types of food and diet, and factors affecting responses. Urgently wanted at the present time, for example, are better data on requirements for fats and fatty acids, amino acids, and some of the more recently recognized vitamins. Also urgently needed now is information on bodily responses to the kind and range in quantity of fat in diets--for example, in relation to cholesterol and lipoproteins in blood--and how responses of the body to fat intake may be affected by other diet constituents. Once determined for persons differing in age, rate of growth, body size, degree of muscular activity, and other conditions of environment or stress, facts on needs for nutrients should be translated by research and educational programs into appropriate and acceptable food practices that will be conducive to health throughout the life span.

Adequate and continuous data are needed on consumption of all agricultural products, on consumer preferences for different forms, and on factors influencing consumer choices to make possible a continuing appraisal of the food and nutrition situation, and to provide information basic to many programs.

To this end, it is recommended that the research program include:

- (1) large-scale surveys of household consumption of all food and other agricultural products periodically, at least once every ten years, with more frequent smaller cross-sectional studies and continuing consumer-panel reports to study special problems, such as seasonality of consumption or effect of promotional or merchandising programs, and (2) studies of the effectiveness of various types of educational and promotional programs in modifying food habits; (3) studies of food consumption in institutions and public eating places and of individuals, classified by age and activity; (4) investigations of household practices in procuring and using food, including quantities of food discarded; (5) expanded coverage and more frequent studies of consumer preferences of various agricultural products or groups of products, including analyses to delineate factors affecting preferences and to develop principles of consumer behavior; and (6) improved estimates of food production and stocks and of domestic distribution and utilization of fiber products, and estimates of the annual consumption of wood products.

Objective 2--Inherent Values of Products

Research Program Needed

In our present atmosphere of rapidly expanding technology, man has little patience with things or processes as they are. Controlled improvement is the universal objective; controls, through which we modify things to make them better serve our wants. To be effective, such controls must have their roots in the body of scientific knowledge about the nature, properties, and behavior of substances. The objective is concerned with accumulation of this body of information about agricultural and forest products. Involved is the study of both measurable and intangible attributes and properties of products--their physical and chemical structure and composition--study with an intensity undreamed of before relatively recent developments in analytical equipment and methods. Research toward the objective is concerned also with the reaction of materials to environment and to treatments--to the physical and chemical changes that occur, for better or worse, during production, processing, storage, and use both of agricultural raw materials and of products made from them. It provides the bases for definition of quality.

Some of the needed information and data are obtained in the course of research directed toward other objectives, such as maintenance and improvement of quality, improved processing methods, or development of new products and uses. But accumulation of such knowledge, consistent with modern needs, requires more than mere compilation of byproduct information. It requires the systematic investigation of product characteristics in order to acquire the full range of knowledge of their properties and behavior that is necessary for effectively exploiting their usefulness. Only agencies whose primary aim is full utilization of farm and forest products, can be relied upon systematically to undertake this task.

Progress to date in obtaining and cataloging such information has been uneven among products and among the many operations and processes performed on them. It probably will always be so because of the refractory nature of some problems and materials, economic pressure and opportunities, and differences in the prospective benefits to agriculture and the Nation.

The importance of foods and feeds demands that research on them should be intensive and concerned with their many attributes. First and foremost should be studies on the nutritive values of perhaps 1,000 food items and how they are affected by geographic source, production methods, processing, storage, marketing, and home or restaurant preparation. This includes work on all of the constituents of food that affect nutrition--carbohydrates, amino acids, fatty acids, minerals, vitamins. Other areas of research on foods and feed concern their interrelations in animal physiology, and their stability and market life; toxicities, growth inhibitors, and allergens; and processing properties. In each of these areas, research programs are moving rapidly into basic relationships and finer subdivisions of the fields. There is urgent need for more and better data on all of these aspects of foods. Among feeds, forages and concentrates rank high in importance because of unsolved nutritional problems and unidentified factors causing serious physiological disturbances in animals.

Because of the importance of wood and its products in the economy, its variety and versatility in use, and its promise as a raw material for conversion, a comprehensive program of research is needed on its properties and composition. It should intensively cover physical structure of wood and of individual fibers, chemical composition of extractives and structural elements, and properties such as mechanical, thermal, and electrical. Research on the nature, composition and reactivity of lignin is especially needed. Millions of tons of it are available yearly in paper mill wastes, yet it remains a chemical enigma. In research on wood properties, more than 1,000 species of commercially important trees are involved. In addition the characteristics and attributes of the trees themselves need study. The Department's position of leadership in research on wood calls for a strong and comprehensive program in this area.

For fibers other than wood and for textiles, the research program should provide the basis for comparison of properties and values of natural fibers with those of man-made ones, for improvement of properties of natural fibers, and for development of new uses for them. Fundamental studies are needed of the ultimate structure and composition of cotton, wool, and mohair, and are desirable for other vegetable fibers. Structure and composition of natural fibers should be correlated with spinning and weaving performance and with functional properties of fabrics made from them.

Recommended Changes in Present Program

For many years Federal and State agencies have conducted analytical research of the kind involved contributing to this objective, but the field is so vast that the progress made is inadequate to the need. Recent advances in techniques now permit acceleration of the program, and fuller advantage should be taken of them. These improved techniques make it possible to obtain more complete information on composition than has ever been available before, thus providing a sounder basis for developing new and better products and better processes with more effective controls.

Taking advantage of the newer techniques, analytical research on foods should be extended to a great many new foods. As new components are identified and evaluated, many of the older analyses must be repeated to bring them up to date. The program has lagged badly in this respect.

Another activity that has failed to keep pace with developments is the compilation of nutritional information into tables and handbooks for dietary planning. Extra effort will be required to clear the backlog of work in the next few years.

It has long been recognized that color, fragrance, flavor, texture, and the ineffable quality called freshness affect consumer acceptance and hence price. Progress has been slow toward isolating and describing the components contributing to these qualities, and as a result, toward learning how to enhance and preserve them. Acceleration of work along this line is justified by the emphasis being placed on fresh fruit and vegetables in the diet.

Closely related to this research is that concerned with the stability of constituents during processing. New processing methods are requiring more and more detailed data on constituents of foods. Still another development calling for expansion of analytical work on foods is the rapid rate at which new varieties and strains of food crops are being bred. These needs for expansion of the program on food composition are cumulative.

Recent work on animal nutrition and physiology has identified a number of maladies as nutritional or related to biologically active substances in feeds. They include growth inhibitors, allergens, toxic substances, and some that interfere with vitamins. Some of these have not as yet been isolated and identified. Others, although known, still defy inactivation or control. The growing importance of livestock products emphasizes the need for expansion of research in this area.

Because the program of research on composition and properties of wood has been meager in relation to the size and importance of the job, expansion of all phases is recommended. The expanded program should stress the fundamental physical and chemical components and their uses in new products, the properties of wood and wood-based products of importance in structures, and methods for increasing the usefulness of wood by modification. Because of the abundant supply, little-used species and low-grade wood should receive special attention. Studies on the nature and composition of lignin and on recovery and use of byproducts available from pulping and chemical conversion processes should also be stressed. Work on gum naval stores should be continued.

Research on cotton, wool, and mohair should be expanded substantially to delineate their inherent and potential properties. Emphasis should be given to research on the microscopic structure of cotton and wool as it relates to processing and use qualities and as affected by growth conditions and heredity. The properties susceptible of improvement by chemical modification of fibers and textiles also should receive special attention. Too little attention is being given to the functional properties of fabrics in the present program. This work should be increased to provide prompt evaluations of present textiles and new ones as they are developed.

All of these researches on the inherent values of agricultural products are basic to sound educational programs promoting understanding regarding their wholesomeness and usefulness and in combatting misinformation of faddists. These researches also are fundamental to the development of new and improved products.

Objective 3--Prospective Demand and Supply

Research Program Needed

Farmers and forest owners and the general public, as well as government agencies, need to be kept informed of the prospective demands for farm and forest products, and of the current and potential capacity of the Nation's resources to produce, process, and distribute these products to meet short and longer term market demands. Even more important is the appraisal of the balance between supplies and market demands and the determination of needed adjustments in production, processing, and distribution to achieve a desirable balance. Farmers and forest owners, and also those who furnish them supplies and who market their products need this information for business planning. Such information is likewise basic to adequate planning of research and action programs, and is essential to general public understanding of the short and long term outlook for farm and forest products and of the desirability of such programs.

The Committee recognizes four main sub-objectives in this general area to which research should be directed: (1) short term analysis of production, consumption, and prospective demand under the activity commonly referred to as "outlook and situation analysis," (2) longer term demand prospects, (3) longer term production prospects and needed adjustments, and (4) processing and distribution capacity.

Recommended Changes in Present Program

Various agencies contribute to research in these areas, and close cooperation is needed among workers in different agencies. Arrangements should be strengthened for achieving teamwork and coordination in this research, and the closest possible liaison should be maintained between research and action agencies.

Research is currently under way in each of the sub-areas mentioned. Our present program, however, is inadequate. It is particularly weak on longer term production prospects and the determination of needed adjustments to balance supply and market demands. Work on farm products in this sub-area has been initiated only recently and it should be continued on a much stronger basis; work on problems of forest products in this sub-area also needs substantial strengthening.

More specifically, the Committee recommends the following changes in our research program.

For short term analysis of production, consumption, and prospective demand, the research on farm products should be expanded with considerable emphasis on improvement in the tools of analysis and on strengthening over-all and commodity analysis. Also, work should be directed toward developing better information on foreign demand.

On longer term demand prospects, the research should be strengthened for both farm and forest products, with early emphasis on improved methodology and with added attention to consumer needs and wants, and to agricultural and forestry relationships with industry. Attention also should be given to developing better basic data for the analyses, including world statistics.

The work in the field of longer term production prospects and needed adjustments should be expanded materially for farm products and strengthened for forest products, with special emphasis on physical and economic research aimed at more objective estimates of potential yields of crops, on better analysis of factors determining rate of adoption of new techniques, and on determining the factors pertinent to needed adjustments in areas requiring shifts in production. The Forest Survey should be accelerated in order to complete as soon as possible the initial survey of the entire United States, including Alaska; and to step up the frequency of regional resurveys to provide more up-to-date statistics on the area, volume, and quality of the timber-growing stock, on the rates of timber growth and harvest by species, and on the losses to destructive agents.

The research on processing and distribution capacity should be expanded with particular emphasis on developing better basic data needed in the analysis of capacity to process, transport, and distribute farm products.

Objective 4--Overcoming Obstacles to Profitable Adjustments

Research Program Needed

Appraisals of prospective market demands for the decade ahead indicate increases in overall market outlets for both farm and forest products. But unbalance is likely to persist in wheat, cotton, and some other products, unless adequate measures are taken to facilitate shifts toward the products with more rapidly expanding outlets. The need for shifting farm land, labor, and other resources from production of surplus products, therefore, will continue to be one of our most difficult production problems.

Farmers encounter many obstacles in attempting to adjust production to achieve a better balance with prospective markets. In some of the specialized wheat areas, for example, shifts to other cash crops or to feed crops, pasture, and livestock under present conditions frequently would result in much lower incomes to farmers than can be obtained from wheat. Research, therefore, is needed to discover alternative farm enterprises that will maintain or improve farm incomes.

It is not enough for farmers to know that other crop and livestock enterprises are available. The obstacles to shifting must be determined, and ways of overcoming them must be found. For example, if some of the more hazardous and less productive wheat and cotton lands are to be profitably shifted to grass or trees, farmers need to know how to establish successful stands, how much it will cost, how long it will take, how income can be maintained during the transition, and what income they can expect after the shift has been completed. The hazards and costs of grass and tree establishment must be reduced if these enterprises are to become profitable alternatives to wheat and cotton. The capital requirements for such shifts need to be ascertained. Also, the size of farm may have to be enlarged to obtain satisfactory incomes from the new system.

If major shifts in production are desirable from the standpoint of farmers as a group and also in the national interest, effort must be directed toward making these adjustments profitable to individual farmers who have to undertake the changes. Research must furnish the background information that will be needed. It is also necessary to develop suggested ways of overcoming specific obstacles that farmers are likely to encounter in attempting to make such shifts. With such information available, farm programs can be geared to facilitate desirable adjustments. But research will be needed also on how farmers are likely to respond to changes in technology, prices, costs, Government programs, and other factors.

Recommended Changes in Present Program

The present research program includes very few studies which focus directly on the obstacles to adjustments in production of farm and forest products. For the most part, production research is concentrated on development of improved technology, with the implicit assumption that, once a discovery is known, farmers will find ways to adopt it. Frequently, however, the profitableness of a new development is not obvious. And if it requires

new capital investment, many farmers may not be able to finance it, or to assume the risks involved in trying it out. The result may be that only the more prosperous farmers are in a position to reap the first benefits from such research. Moreover, until recently, insufficient research attention has been devoted to the problems of the Great Plains and other areas where major shifts are needed. In these areas the research job is not completed with development of single improvements, such as a better adapted grass. This is important, but additional research is needed to determine how such a grass can be combined into profitable grazing-livestock farming systems and to find out what must be done to enable farmers to make the shift.

Direct focus on obstacles to achievement of needed adjustments requires program changes along the following lines.

Research on production responses to changes in technology, prices, costs, Government programs, and other factors should be greatly expanded in order to explain how farmers react to such changes. These studies should cover major types of production in different regions, and national summaries of results should be prepared.

Production adjustment studies that emphasize discovery of the obstacles to desirable adjustments and development of means of overcoming them should receive major emphasis (see also Objective 13). Special aids should be developed for the smaller farms, and availability of nonfarm employment opportunities should be explored; also, the ability of rural people to take advantage of their best income opportunities should be studied.

Research on forage, pasture, and feed grain production needs to be expanded in order to facilitate shifts to grassland-livestock farming. More emphasis is needed on studies of timber yields in managed forests; also on technical and economic research to analyze forest possibilities on cropland physically unsuited for tillage. Potential replacement crops for wheat and cotton need to be screened and analyzed to learn their technical and economic possibilities. Ways of maintaining livestock enterprises under highly variable weather and feed conditions also require further emphasis.

Studies need to be undertaken to show how capital can be provided to promote needed adjustments in farm and forest production, and how repayment can be geared to the flow of income. Expansion of forest credit studies should emphasize capital needed for timber growing on land unsuited for crops, and should explore the need for combining credit and insurance against loss by fire and other hazards.

The changes needed in farm sizes and in tenure to facilitate shifts from wheat to grass in the Great Plains and from cotton to grass and timber in the South should be analyzed, and research undertaken to learn how obstacles can be overcome. The obstacles to efficient timber production on small tracts need further emphasis.

In many areas, research will be needed to determine how changes in taxation, zoning, and other institutional arrangements can be used to facilitate desirable adjustments, such as reduction of taxes to promote shifts from wheat to grass or to promote timber production.

Objective 5--Efficient Structures and Equipment

Research Program Needed

In a society moving steadily toward greater specialization, increasing use of power, and concentration of population in urban areas, agriculture can maintain its place only through more efficient production, processing, and marketing. To a greater and greater extent improved efficiency is dependent on mechanization of operations and on the buildings and facilities designed for the use of machines.

In agricultural production, about a third of the capital investment on farms and more than a fourth of the inputs consist of buildings, machines, and production supplies. These are closely related to labor, which accounts for another third of the inputs. These production facilities have a value of about \$30 billion, with annual maintenance and replacement expenditures of about \$3 billion. The shift from animal to mechanical power, rural electrification, and research leading to new or improved methods and products has made obsolete many of these facilities.

Processing food and fiber is an expanding and integral part of agriculture. More and more food is being prepared outside the home, and industrial outlets are being found for more agricultural products. Modern processing is essentially a mechanized operation. Its efficiency, therefore, depends upon having the right combination of machinery, plant capacity, and layout in relation to supplies of raw materials, transportation, and markets.

In marketing, the overall problem is to move larger quantities of more kinds of products to more great centers of population in shorter time and at lower costs. Integrated transportation systems and mechanized handling through efficiently planned facilities present the greatest opportunities here.

Research and development work on equipment, buildings, and facilities is undertaken to meet specific operational problems or to implement results of research in another field. It must be geared, therefore, to the size and kind of research program in these other fields. Each new crop, process, or product presents needs for new or modified equipment or other facilities. Expansion of research on the scale recommended under other objectives in this report will require a tremendous increase in applied engineering research.

Recommended Changes in Present Program

The present program has a number of weak spots that should be strengthened. Engineering development in the production field has lagged behind crop and livestock research. Equipment manufacturers have been relied upon heavily for development of production models of farm and forest machinery. Development of equipment and commercial processes for new products arising from utilization research has been left largely to industry. Availability of electric power on farms has created unexploited opportunities for development of equipment to use it. Except for fire protection and forest road construction, almost complete dependence has been put on manufacturers for equipment used in forest production. Marketing facilities need much improvement, and only a start has been made at applying mechanized handling methods in this area.

The number of opportunities for improvement of equipment and buildings is limited only by the number of products, operations, and situations involved in producing, processing, marketing, and consuming farm and forest products. In a world changing as rapidly as today's, the number is increasing rather than diminishing. The job is continually expanding. In no significant segment can work be curtailed without loss. Some areas will, however, yield greater returns to research than others.

Increased developmental work is needed on equipment and buildings for livestock production. Present methods require too much labor in getting forage crops from field to livestock, and further mechanization of handling is needed. Better storage structure, such as silos and grain storage facilities, are needed; also, improved equipment for preparing feedstuffs for storage. These improvements relating to feeds must be combined with new functionally-designed shelters and buildings for housing livestock.

There are many opportunities to make more use of electric power on the farmstead for materials handling and for product conditioning, processing, and packaging. Drying of grain and oilseeds, with farm storage, is likely to be profitable if suitable equipment and structures can be designed.

In field equipment, emphasis should be put on tillage for soil and water conservation and on irrigation equipment in order to reduce the weather hazards to production and on harvesting equipment to increase operational efficiency for crops having special problems such as cleanliness.

Forest production and harvesting operations have always involved much hand labor. Recent development of power saws and tractor equipment has greatly reduced labor requirements for harvesting, but little progress has been made on such cultural operations as pruning and thinning. No

planting machine suitable for rough and rocky ground is yet available. And the mechanization of protection of forests from fire, insects, and disease needs aggressive development. Aerial methods of attack appear promising, but ground methods must be developed as supplements or alternatives. With increased emphasis being given to forest genetics and tree improvement, seed orchards for superior strains will be developed and will call for mechanization of seed collection, cleaning, and conditioning. Other broad areas for equipment improvement are in bulk handling and transportation of forest products, field processing of materials such as pulp chips, and equipment for continuous pulping and chemical conversion of wood.

The increasing emphasis being given to development of new products from farm and forest crops and to improved processes creates a need for a substantial increase in work on new equipment. In developing this new equipment and improving what is now available for freezing, canning, and drying, special attention should be given to the needs of small to medium-sized plants that might be dispersed close to producing areas. This subject of plant size and of location with respect to production area and marketing channels is one on which research should be expanded, particularly so in regions where crop shifts are occurring. These location studies should be accompanied by others concerned with design and layout of plant for greatest efficiency on various scales of operation.

One of the outstanding needs in the passage of farm products through marketing channels to the consumer is to reduce the number of times they are picked up or moved by hand. This can be done most readily by mechanizing their handling, or by bulk handling methods. Expansion of development work toward this end is needed. Such equipment, to be most useful, should be used in warehouses, wholesale markets, or assembly facilities designed for them. Such facilities must also be fitted to both rail and truck transportation. Integration of these factors into efficient operating units for handling a wide variety of products is a field of research in need of expansion.

Objective 6--Conservation of Basic Resources

Research Program Needed

Nothing is more fundamentally important to American agriculture than conservation and improvement of our country's renewable resources. In doing this, we not only assure ourselves of the capacity for sustained production of good quality farm and forest products, but we make it possible to supply the needed environments for forest recreation, the necessary habitats for wildlife, and the healthy watersheds required for reduced floods and high yields of usable water. To these ends, a strong and comprehensive research program is needed to develop practices that will conserve and improve our basic resources of soil, water, forest, and range, and of germplasm of plants and animals.

Soils are being built up and torn down at the same time. Use of crop residues, manure, fertilizer, and other good management practices build up soil productivity. Leaching, erosion, crop removal, and oxidation of organic material all too often are depleting soils faster than they are being built up. Reversing this trend involves development of methods of soil management for farms, ranges, and forests that provide a basis for maintaining and improving productivity.

Closely associated with the problems of soil are those of conserving and improving the basic water resource. Our Nation is plagued on the one hand by accelerated runoff and erosion, and on the other hand by a growing scarcity of usable water. On farm lands, water and wind carry away the most fertile parts of our soil. Present knowledge of how to retard these physical losses leaves many questions unanswered. Also, infrequent or irregular rainfall limit crop production in many areas; yet only a start has been made in exploring the possibilities of irrigation. Scarce water in arid regions needs to be used with care. In humid regions, supplemental irrigation can probably increase productivity and counteract the more serious effects of drought, but availability of water, and the cost of irrigation development must be considered. The precipitation that falls on forest and range lands supplies three-fourths of the water that feeds our streams, lakes, and underground basins. How these lands are managed has a vital influence on stream behavior and water quality. Development of improved practices to prevent watershed degeneration, to rehabilitate watersheds already damaged, and to increase the yield of usable water is therefore a prime requisite of the needed research program.

The basic forest and range resource includes, of course, besides the bare soil, the growing stock of timber and the forage. A healthy forest is capable of supplying from growth, in the form of interest on the growing-stock capital, a sustained yield of forest products at a reasonably high level, while at the same time providing favorable conditions for vital watershed protection, essential habitats for wildlife, and required environments for forest recreation. Likewise, a healthy range can furnish a sustained production of forage for livestock and big-game grazing while at the same time providing a good watershed condition that promotes flood prevention and retards sediment movement.

In the earlier years, our forest and range resources were used for lumbering and grazing without serious thought of depletion. In more recent years, concern over the decreasing quantity and quality of timber and forage has resulted in a limited research program to protect and replenish them. We now know how to avoid some of the extreme effects of imprudent exploitation, but there needs to be developed a broad, factual basis for resource management that will result in more sure-footed conservation and improvement. Examples of major problems are: Timber-growing stock needed to sustain potential demands for forest products must be much greater than at present; one-fourth of our commercial forest land (120 million acres) is poorly stocked; fifty million acres are nonstocked and in need of reforestation; inferior hardwoods are taking over many of the better quality softwood sites; timber quality is declining; destructive agents, such as fire, insects, and diseases, are taking a heavy toll; the increasing need for usable water requires adjustments and some curtailment in timber production; forest recreation is expanding and requires further adjustments in forest use; deer and other wildlife need their fair share of the resources; the amount of range forage for livestock and big-game grazing is diminishing. Accordingly, studies to develop new and improved methods of forest and range protection and management for all regions of the country--methods that seek to build up and maintain good quality growing stocks for maximum wood-industry and grazing use consistent with the growing demands for the other uses--are essential parts of the needed research program.

Conservation and improvement of plant and animal germplasm is another basic field requiring prominent attention in the needed research program. With respect to plant germplasm, two principal phases are involved: adequate seed storage and preservation of vegetatively propagated stocks, with provision for periodic reproduction; and introductions from foreign lands, with facilities for handling the introduced materials, including quarantine where applicable. These two phases complement one another and together result in a germplasm bank which is essential if breeders

are to improve the productive potential of our farm and forest crops and meet the requirements of constantly changing conditions brought about by disease, insects, and market demands. Also, important to conservation and improvement of germplasm are the specialized forest-tree breeding arboreta and the National Arboretum. This latter not only serves the purpose of preserving germplasm but has valuable educational features as well. With respect to animal germplasm, preservation may be achieved by artificial storage of semen and ova or by maintenance of "living" museums; and improvement by introductions from foreign sources. The research so far conducted on safeguarding and improving animal germplasm has scarcely scratched the surface of the difficult problems involved.

Recommended Changes in Present Program

Research currently is under way in all of the above problem areas. Our present research program, however, is stretched too thin to deal adequately with the many problems, and there are conspicuous imbalances and some rather serious gaps. The research programs on soil and water problems are closely related and ought to go hand in hand, but instead the water program lags behind. Also, there is imbalance in the soil research on farm lands, with notable gaps in the Appalachian, North Central, and Northeastern regions. Soil research on forest and range lands is quite inadequate generally.

The research on forest and range problems is weak in the following respects: There is practically no research on the problems of rapidly expanding forest recreation; there is a relatively small research program on problems of forest fires, considering the damage they cause and the huge sums spent annually by the Federal and State governments to control them; only a small effort is going into problems of forest wildlife habitat management; there is no forestry research in the interior of Alaska, where some 40 million acres of forest land is beginning to be drawn upon by commercial cutting.

Virtually no research of an organized nature is being conducted on problems of conservation of animal germplasm. Also, the programs of economics research on problems concerning conservation of our basic agricultural and forestry resources are small relative to need and relative to the general level of many of the other programs.

The Committee recommends substantial expansion of research in all conservation problem areas, and urges that the research gaps be closed and imbalances corrected as soon as feasible. More specifically, the Committee recommends the following changes in the present program:

Soil resources.--Expand, for both farm range and forest lands, basic research on soil behavior, soil-water relations, and erosion control methods; economics research aimed at improving effectiveness of public policies and programs and at guiding allocation of soil resources among major uses; research to provide an improved basis for an accelerated nationwide soil survey, including the development of suitable soil classification and mapping systems for forest and related range lands. To the extent feasible, the East should be favored in soils research expansion because of the relatively stronger present program in the West. Also, for the immediate future, research accent should be on conservation and on improvement as needed, rather than on problems of development of new land resources, such as by clearing, irrigation, and drainage. The soils problems are closely related to water problems listed below; accordingly, the two programs should be maintained in reasonable balance.

Water resources.-- Expand the following: Studies of sediment movement; watershed hydrology studies on farm lands, with attention to better balance geographically; forest and related range watershed hydrology and management studies, with emphasis on plugging geographical gaps and on strengthening research on problems of water yield; studies of water conservation on nonirrigated land, and control of aquatic weeds and phreatophytes relative to irrigated land; water resource economics studies, with attention to alternative programs as well as analysis of present and projected programs. Initiate work on a nationwide water-use inventory and accelerate research on water rights. Increase efforts to achieve close cooperation in water and soil research among the research units involved.

Forest and range resources.--Expand programs of fire, insect, and disease research with relatively greatest emphasis on fire; stress work on indirect control of insects and diseases, such as by forest management measures and biological control; expand forest management studies with emphasis on problems of the West but including problems in all parts of the country involving especially plantation spacing and yield, natural and artificial regeneration of timber stands, tree improvement, weed-tree control, and basic research on forest soils and tree physiology and genetics. Initiate forest research in the interior of Alaska. Expand range research, with emphasis on problems of grazing management; on rapidly developing problems of dual use of ranges by livestock and big game; on range inventory methods; range reseeding; noxious plant control; and range insects and diseases. Initiate a nationwide range inventory (including pastures). Initiate forest recreation research. Expand forest and range economics studies with special attention to problems of farm forestry, forestland tenure, multiple use of forest land, and costs and returns on range lands.

Plant and animal germplasm resources. -- Expand work on plant introduction and provide adequate operating funds for the new seed storage facilities at Fort Collins, Colorado. Also, expand facilities and research on forest tree breeding aboreta and provide adequate funds for the National Arboretum. Initiate studies on methods of artificially preserving animal semen and ova, on methods of safely importing foreign stocks, on means of identifying superior animal germplasm, and on improved ways of distributing existing stocks in order to safeguard them against loss. The Committee recognizes that research on animal germplasm is expensive and that costs may place practical limitations on the size of the program; nevertheless, it urges that a start be made in this field as soon as feasible.

The Committee believes somewhat closer cooperation in the planning and carrying out of research in the above areas can be achieved on the part of the various research units involved, and accordingly so recommends. Directors of the public research concerned should take appropriate steps to facilitate and foster cooperation among the workers on the various problems of conservation.

The Committee also wishes to stress the importance of maintaining close liaison between research and action programs. Such liaison can help orient the research attack and hasten the adoption of new and improved practices.

Objective 7--Hazards in Production and Marketing

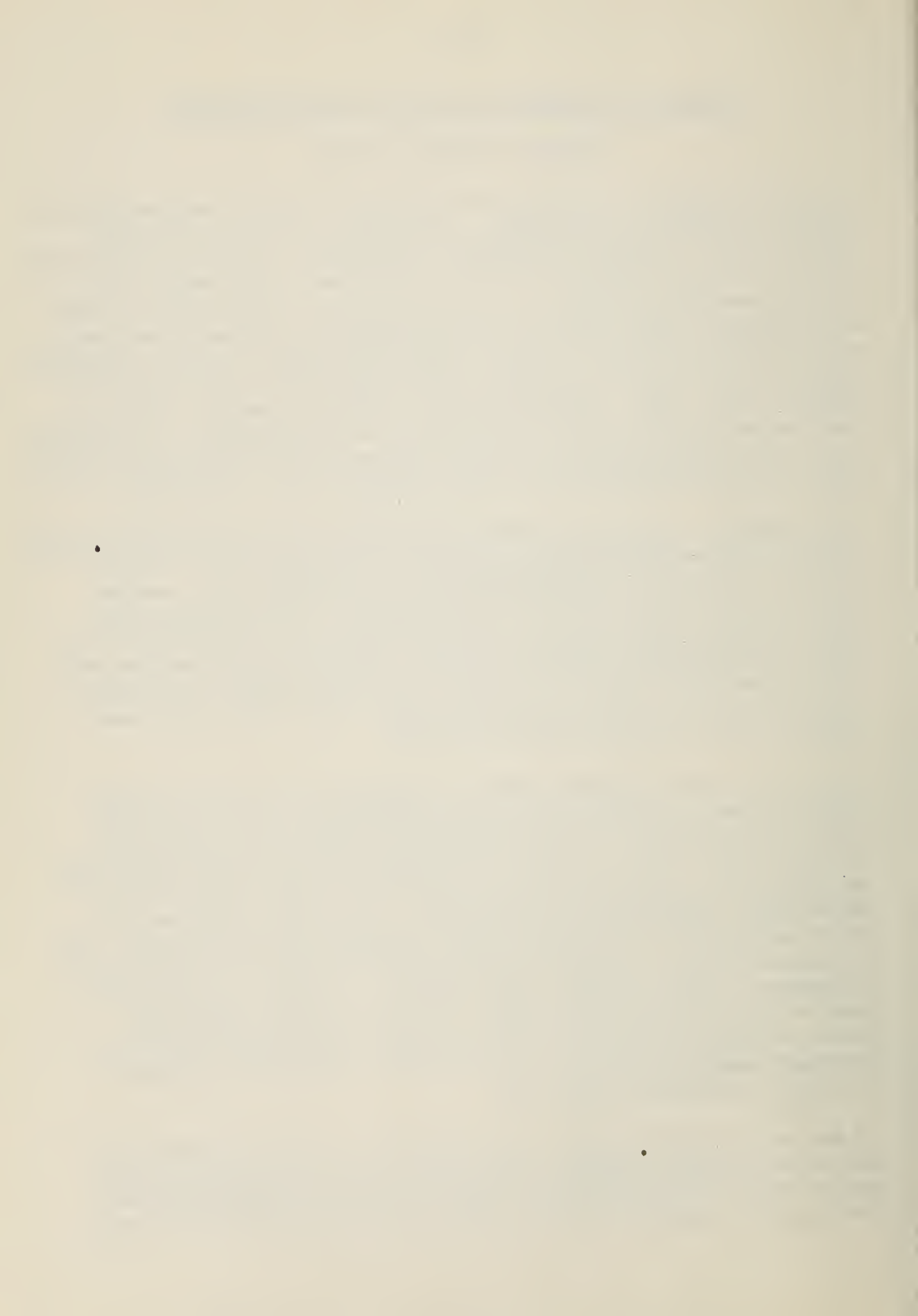
Research Program Needed

Biological, physical, and chemical hazards beset man's plants and animals and their products at every hand. As examples, viruses, rickettsia, bacteria, fungi, protozoa, nematodes, trematodes, cestodes, mites, ticks, and insects may cause diseases of, or prey upon, crops, forests, and livestock and their products. Less desirable plants and animals compete for living room and for plant or animal nutrients. Insects, birds, and wild mammals prey upon domestic animals and plants, actually consuming thousands of tons of feed and crops. Sometimes heat, cold, light, wind, lightning, fire, water, and dust destroy or interfere with the normal development of man's livestock and crops, including forests. On occasion toxic and harmful substances in feed, soil, water, air, and in man-applied sprays, dips, and dusts injure or kill desirable plants and animals.

These diseases, pests, and other hazards affect adversely both the quantity and the quality of agricultural products, the quantity by either killing animals or plants or slowing down growth or production rate, and the quality by interfering with normal development, and both quantity and quality through deterioration or outright spoilage of stored products or those moving through marketing channels. Estimates indicate that total annual losses due to damage or injury to, or destruction of, plants and animals and their products are nearly half as large as the total annual realized output of farm and forest products.

The public research agencies have some research under way on most of these hazards. In some instances, application of knowledge coming from such research has nearly or completely eliminated losses from certain hazards. Thus, research with hyperkeratosis in cattle disclosed that highly chlorinated naphthalenes caused the disease, and cattle were getting these naphthalenes from lubricants. The disease disappeared when manufacturers discontinued adding naphthalenes to lubricants. But in many instances, the knowledge developed by research is not sufficient to eliminate a pest or hazard. Its application results in nothing more than amelioration of harmful effects. Thus, boll weevils still cost cotton producers millions of dollars annually even though research has developed methods of control. In some fields, such as air pollution, very little research is under way.

As the population of the country grows and the demand for agricultural and forest products increases, more plants and more animals must be grown. Other things being equal, losses from transmissible diseases and parasites usually increase geometrically as numbers of susceptible



plants or animals increase arithmetically. Methods of control and prevention that are fairly satisfactory today, then, may be quite inadequate 10 years from now.

A vigorous research program is necessary if the harmful effects of diseases, pests, and other hazards are to be minimized or prevented so that production and marketing from farms, ranches, and forests may keep pace with foreseeable increases in demand. Basic information about the life processes of the agents that cause transmissible diseases, the parasites, predators, and pests that are harmful to man's plants and animals and their products, and those plants and animals that compete with domesticated species for nutrients and living room must be acquired through research so that protective procedures may be developed. This must include studies of the ecology, taxonomy, anatomy, and physiology of such diverse forms of life as viruses, rickettsia, bacteria, fungi, protozoa, nematodes and other worms, parasites, insects, mites, ticks, predatory birds, rodents, wild mammals, and weeds and weed trees.

The very complex problem of host-parasite relationship in transmissible diseases needs additional research. Techniques for ameliorating or curing transmissible diseases, for developing host resistance to their causative agents, and for prevention of exposure to such causative agents must be developed by research if losses from such diseases are to be controlled or prevented. Development of resistant plants and animals by breeding and selection, and biological control of insects and weeds merit special attention. New fungicides, herbicides, insecticides, and tickicides are bringing relief from many diseases and pests, but there is great need for further research in this field.

Additional research is needed on the harmful effects of heat, cold, droughts, floods, winds, and dust, and on harmful pollutants or contaminants of air, water, feed, and soil. The hazards associated with the use of chemical sprays, dips, and dusts also merit additional research. Special attention should be given to developing or introducing desirable plants that are tolerant to heat and cold, and desirable animals that are heat-tolerant. The very rapid industrial expansion occurring in the United States is bringing many new problems with pollutants and contaminants. And the rapid increase in both variety and volume of fungicides, herbicides, and insecticides makes it mandatory that more research be done with this group of substances and what their broadcast use is doing to the natural biota.

Research is needed to develop actuarial bases for insurance of all types of farm and forest property against all types of losses from diseases, pests, and other hazards; to develop model insurance laws; and to find means of providing such insurance at the lowest possible cost.

Recommended Changes in Present Program

The Committee recommends the following needed changes in the present program:

Harmful insects--Expansion of basic research is needed in the physiology of insects, the toxicology of insecticides and poisons, the synthesis and mode of action of attractants and repellents, biological methods of controlling insects, including predators, parasites, and transmissible diseases, and the sterile male technique, and the genetics of resistance to insects. There should be increased research with synthesis and methods of testing insecticides, with equipment and methods for applying insecticides and repellents in both production and storage, and expansion of efforts to find, by exploration and introduction, plants and animals that are resistant to insects.

Diseases, nematodes, and other parasites (not including insects) that are harmful to plants and animals and to their products--Expansion of basic research is needed on host-parasite relationships, the relation of the chemistry and enzyme systems of causative agents to their pathogenicity, the nature of resistance to disease, and methods of breeding resistant plants and animals. Increased studies should be made of growth requirements of disease-causing agents, methods of destroying such agents, methods of diagnosis and treatment of disease, the detection of carriers of disease, and methods of protecting products from exposure to disease or spoilage causing agents. Research should be initiated on the relation of environment and nutrition to resistance to transmissible diseases and parasites.

Damage by animals such as rodents, birds, predators, and game animals--Changes needed in the present program are expansion of all research presently under way, including studies of the ecology, migrations, food habits, and rate of reproduction of damage-causing mammals and birds, and methods of controlling these animals. Research should be initiated with repellents and with rodent-proof or rodent-resistant containers.

Weeds (including weed trees) that interfere with production of desirable plants and that are poisonous to livestock--There is need for expansion of all phases of research with weeds, with emphasis on biological control; on synthesis, mode of action, and efficacy of herbicides; good grazing

practices, good cultural practices, and the use of fire as control measures; basic ecological and physiological studies; and on the broad subject of livestock poisoning by toxic plants.

Weather and other environmental hazards--There is need for increased research on animal and plant and product tolerance to heat, cold, drought, humidity, and wind, and the physiological bases for such resistance; on development by genetics of strains that can withstand unfavorable weather; and on lightning storms, including methods of preventing damage from them. In cooperation with the Weather Bureau, research should be initiated to develop better weather information for farmers. Research on the relation of weather to crop yields and farm income should be initiated.

Forest fire damage and fire that destroys or damages all types of agricultural products and structures, machinery, and equipment used in farm production, processing and storage--Needed changes in the present program include expansion of all basic and applied research on forest and range fires; on methods of fireproofing fabrics and other materials or making them fire-resistant; and initiation of a research program on prevention of fire losses of farm structures, storage facilities, and agricultural crops.

Air, water, feed, or soil pollutants or contaminants that are or may be harmful, toxic sprays, dips, and dusts, and organic and inorganic poisons--Very little research is presently under way with pollutants or contaminants that may be in air, water, feed, or soil. This work should be expanded to include studies of the harmful effects of these substances on plants and animals and how to prevent such harm; methods of preventing such substances from polluting or contaminating air, water, feed, and soil; and the tolerances of plants and animals for these substances. The very rapid increase in the use of toxic sprays, dips, or dusts as insecticides, herbicides, and fungicides has developed an acute need for marked expansion of research on the effects of these compounds that may possibly be harmful to either plants or animals; methods of measuring these effects; and methods of treating exposed plants and animals to alleviate these effects.

Insurance against agricultural risks--There is need for expansion of what little work is presently under way in this field and for initiation of a comprehensive research program. It should include research on all types of losses of livestock and growing and harvested crops, including trees, in the different regions of the country so that actuarial bases may be available; on model insurance laws; and on types of insurance that will provide maximum protection at minimum cost.

Objective 8--Protection in National Emergency

Research Program Needed

The U. S. Department of Agriculture has delegated to it (FCDA delegation number 2, September 8, 1954) the following specific emergency responsibilities: (1) Plan a national program and direct Federal activities concerned with research, diagnosis and strengthening of defensive barriers, and control or eradication of diseases, pests, or chemicals introduced as agents of biological or chemical warfare against animals or crops. (2) Plan and direct Federal activities, and provide technical guidance to States, in connection with an over-all food program aimed at maintaining adequate emergency food supplies for attacked or support areas. (3) Plan a national program, direct Federal activities and provide technical guidance to States concerned with the prevention and control of fires caused by enemy attack in rural areas of the United States.

In the interests of continuing national security, appropriate research and action agency planning must be conducted as part of the peacetime program of the Department and states so that they are in position to discharge adequately emergency responsibilities. Many of the regular research and action programs contribute to emergency preparedness, but direct attention must also be given to the specific problems peculiar to protecting our agricultural resources against enemy attack and assuring the Nation of availability of the essential products of agriculture. To this end, there are three main sub-objectives to which the research and action programs should be aimed: (1) To assure our cognizance of the nature and size of emergency needs for food and other products of agriculture and of the things needed to get these products to the user; (2) to assure our ability to satisfy these needs through adequate production, processing and distribution; (3) to assure maximum protection, in case of enemy attack, for farmers, crops, animals, soil, water and the other elements upon which the Nation is dependent for the processing and distribution of agricultural products.

Recommended Changes in Present Program

Our present programs are weak in several important respects. Inadequacy of research and support programs which supply, in connection with peacetime programs, much of the basic information needed for emergency use is the chief factor responsible. This situation can be corrected to a considerable extent by means of the expansion suggested in appropriate programs under other objectives of this report. Included in this category of needs are the more rapid development of nutritional reference data, more stable food forms, timber inventories, and methods for the

detection, diagnosis, and control of plant and animal diseases and pests. In the specific areas of the objective, however, the Committee recommends the following additional changes to place programs on a balanced and adequate basis to meet emergency needs.

We are not accumulating rapidly enough many of the pieces of information needed to make adequate working estimates of the size and nature of emergency needs for food and other products of agriculture. Among deficiencies in this respect is a lack of food inventories at all points in distribution channels from farm to home. Lacking also is information on farm manpower required per unit of production for different types of farming operations and on fertilizer and feed needs for different farming areas. We have an incomplete inventory, including age, type, and condition, of tractors and other farm machines. Accumulating this vital information is of first importance in balancing the research program under this objective, and balance can be obtained fairly readily through a modest augmentation of present programs which should be initiated promptly.

The research programs aimed at assuring our ability to meet emergency needs includes no research in a few important areas and lacks adequate strength in several others. Work should be initiated to establish domestic sources of the two insecticides rotenone and pyrethrum, and to develop a substitute for coconut oil from domestic fats. Both pyrethrum and coconut oil are on the Strategic and Critical Materials Stockpile List, but no research is now being done to establish domestic sources. Greater effort needs to be applied in all aspects of current research on the establishment of domestic sources of critical hard and soft fibers and castor oil, and on the development of tanning agents from domestic agricultural materials, to supplement continuing studies on development of canaigre tannin. Increased research attention needs to be given also to means for assuring availability of adequate electric power on farms during emergency. The Committee recommends no research on the following items on the Strategic and Critical Materials Stockpile List, because it feels that current knowledge, and the probability that certain industrial products will suffice in emergency, places us in a favorable position with respect to these items: Feathers and down, palm oil, quinidine, shellac, raw silk, silk waste, and noils.

No specific additional changes are recommended in the phases of our research programs aimed at protecting agriculture in the event of enemy attack. The Committee recommends, however, continuation of present research assistance to the Department of Defense and Atomic Energy Commission in this field at the levels permitted by funds transferred. Continuation and expansion is also recommended, as transferred

funds will permit, of surveys and studies conducted to obtain requirements data for materials and facilities needed to assure adequate processing and distribution of food and control of forest fires in an emergency.

The Committee feels that the closest possible liaison should be achieved and maintained in the area of this objective between research and action agencies.

Objective 9--Efficiency in Production, Processing and Marketing

Research Program Needed

The Federal and State research programs have given major attention for many years to problems concerned with increasing efficiency in agricultural practices. When efficiency is defined as "the relative capacity to produce maximum economic returns from the energy, time, and money expended," practically all of the research could be included either directly or indirectly. Many details of needed programs and recommended changes in certain areas appear in other sections of this report.

An adequate research program includes over-all consideration of plant and animal production; the control of pests, diseases, weeds, and other sources of loss; the management of water and soil resources; efficient design and operation of farm machinery, structures, and other facilities; improvement of equipment and supplies needed in production and marketing; fuller utilization of farm and forest products; better marketing, processing, transporting, storage, grading, and utilization of plant, animal, and forest products; and more effective organization and financing of farms and of processing and distributing enterprises.

The annual losses to farm and forest crop production from disease, insects, mechanical damage, weeds, and hail and other weather hazards remain high even when the best recommended control practices are followed. Crop production cannot be efficient if it is subject to such tremendous losses. Therefore, continuing research is necessary to reduce the loss, by the use of improved varieties or strains of crops and improved cultural practices.

Livestock research is needed to reduce costs of production through increasing the yield per unit of livestock, improving the yield of livestock per unit of land, and reducing the cost of labor and capital investment of the farm. Increased efficiency can be realized also by improving product quality and finding new uses for livestock products.

A recent review of the Nation's timber situation by the Forest Service shows that 60 percent of the commercial timber lands are in small ownership. We have a shortage of high-quality timber and an abundance of low-value timber. One of the main reasons for this is that the high-quality timber has been selectively harvested, leaving the small and cull trees and less valuable species. The forestry condition is poorest on small ownership tracts. Increased efficiency can make the practice of

forestry more profitable. This requires improving timber management techniques and developing profitable processes for utilization of low-value timber and woods and mill residues.

Machinery, equipment, appliances, and buildings represent about one-third of the capital investment and more than one-fourth of the input cost of agricultural production. Research is needed to make these farm facilities less costly and to design them for more efficient, labor-saving operation, with less waste and better protection of quality of products.

Economic research is needed to develop farm operating methods and management practices that will cut costs. Farmers need guidance, for example, on how much fertilizer it pays to apply to different crops, how many cultivations and sprayings are justified in terms of increased yield or higher quality product, and at what point the increased yield of meat or milk ceases to pay for heavier feeding of livestock, taking account of comparative prices of products and of feedstuffs. They need help in determining what scale of operation is necessary to provide enough use of particular kinds of machinery to justify investment in them. Above all, they need help in deciding what combination of enterprises will give full employment to their labor and management capacities while providing the most profitable use of their resources of land and capital.

In the marketing of farm products, imperfections and inefficiencies in the marketing system often fall hardest on the farmer, because retail demand for farm products is closely keyed to the consumer's income while the charges made for marketing services are relatively inflexible. A central objective of marketing efficiency research is to put the spotlight on the location of these imperfections and inefficiencies, and to develop information as to ways and means by which they can be minimized or eliminated.

Improved efficiency and savings made through marketing, purchasing, and service cooperatives are directly reflected in an improvement in the farmer's income, either as increased receipts from the sale of his products or as lowered costs of the production supplies and services he purchases. Such improvements not only benefit farmers who are members of cooperatives but benefit all farmers by requiring competitors to meet the competition of efficient cooperatives.

There is need for improvement in efficiency of utilization and marketing methods for forest products. It is not feasible to "weed" timber stands in the same manner as other agricultural crops. We must develop economical methods of utilizing and marketing low-value trees. The answer is to develop better and new processes to use this material. Also the use of

presently little-used species and residues and the reduction of losses in processing will relieve the drain on higher quality trees. This will improve the quality of residual stands. In addition to improving forestry, the development of new and better processes and marketing methods will result in large savings to the consumer. It is estimated that seasoning losses amount to about \$120,000,000 a year. If we save only 1/10 of this by developing better practices, the saving will be over \$12,000,000 a year. This is only one example of the importance of research on more efficient utilization. Research on improving the efficiency of utilization of farm and forest products is an essential part of the over-all effort to achieve and maintain a healthy condition of agriculture in the United States.

It is essential that industrial processes employing farm and forest products as raw materials be inherently efficient to enable the products to compete with raw materials from nonagricultural sources. More efficient processes are needed to preserve the farmers' markets in many areas. Competition from synthetic resin paints, plastics for shoe soles and other leather goods, and especially from synthetic fibers requires a continuously expanding research effort to increase efficiency and thereby maintain the use of farm products in these important fields.

Recommended Changes in Present Program

Research is currently being done on all major problems in this field but, under present appropriation levels, some are not adequately supported to assist in solving problems needing the coordinated efforts of several agencies. Expansion of all phases of the current program is recommended, although the magnitude of the needed expansion varies from the sub-areas in order to provide better balance. For example, research to develop new crops and to increase the efficiency of utilization of all agricultural materials needs greater expansion than crop production research.

In farm crop production, there should be increased research on the more profitable utilization of land resources, and on products that offer some promise of yielding greater returns to the grower. This would involve the testing of new crops and the cooperative planning of this type of research with the appropriate agencies dealing with economics and utilization. Emphasis should also be given to basic research in soil chemistry and crop physiology which would contribute to the practical end desired. More emphasis is needed also on research to reduce the hazards that lower the efficiency of production. This would require expansion in plant and animal breeding programs and disease control.

Forest crop production research must be balanced with stronger forest-product utilization and marketing research, since good forestry practice requires efficient utilization of forest products. Research should be expanded to develop more positive regeneration techniques, and a more fundamental approach to this problem is needed.

Range and forest wildlife habitat research should be expanded to develop basic principles and practices for improving habitat management and for intelligently integrating game and livestock grazing on ranges. Research should also be expanded to improve management of ranges used by livestock alone to determine the effect of range management practices on watershed management, to work out more economical methods for control of undesirable plants, and to develop more efficient methods of range reseeding and fertilization.

An expanded program for improving the efficiency of livestock production and preventing disease is required to meet future goals for human needs. Increasing the efficiency of animal units will be a highly effective means of fulfilling future requirements. Expansion of basic research in genetics, physiology, nutritional requirements, and disease control is required in this area.

Mechanization of farm operations and improved design of farm structures contribute greatly to efficient production of crops and livestock. Under current levels of support, agricultural engineering research has lagged behind that of other fields. Therefore, a higher level of expansion is needed.

Research in production economics is an integral part of research on the efficiency of farm, forest, and livestock production. The research program in this area has been very inadequate. The Committee recommends considerable expansion in this sub-area, so that cooperative work can be initiated on additional problems. There is need for expansion of research to provide economic evaluation of alternative physical production possibilities under farm conditions when land or other resources are shifted from one use to another. More information is required also on the organization and operation of farms, to decide what changes in resource use will maximize economic returns under different price conditions.

Research on marketing of farm and forest products has not received proper emphasis. Since labor costs are a chief factor in increasing costs of marketing, emphasis should be given to work organization, equipment and methods, and plant layout that will save labor in all types of operations. It should likewise emphasize analyses of economies of scale in different

processing and marketing enterprises. Rising transportation costs highlight also the need to emphasize studies to determine the most advantageous locations for performing different functions, and ways of making most efficient, integrated use of transportation facilities.

Substantial increases are recommended for research to increase the efficiency of utilization of farm and forest products. These recommendations are given in detail for farm crops and in part for forest products in Objective 11. Profitable utilization of all forest products is required for efficiency. Expansion of research on integrated utilization of forest products is necessary.

Objective 10--Product Quality

Research Program Needed

Improvement in quality of farm and forest products offers an opportunity for agriculture. There is a limit to the physical quantity of food that people want to eat, and a similar thing is true also for many textile products. But, especially in a prosperous economy, the demand for greater variety and higher quality of products is much more expansible. Farm resources devoted to increasing mere physical output often result in products surplus to market demands except at ruinous prices, whereas by devoting resources to improving product quality or to tailoring products more perfectly to special demands, profitable market outlets may be found.

Hence, research to make possible products of higher quality, to assure maintenance of that quality in processing and marketing channels, and to help household consumers, both family and institutional, and other final users both to obtain products best suited to their needs and to take full advantage of superior quality--research with these objectives can make a particularly important contribution to the welfare of farmers as well as of the Nation in periods of abundant supplies of farm products.

very good

Research concerned with quality is broad in scope. The effect on quality should be taken into account in work related either to the inherent, genetic characteristics of products, to the environmental conditions surrounding their growth, harvesting, and subsequent handling, or to the operations to which they are subjected in production, processing, and final use. Hence, quality maintenance and enhancement is one among other objectives in a great deal of research. The need is to assure it sufficient emphasis, lest it be overlooked in the pursuit of other aims such as increasing yield or saving labor.

This immanence of quality aspects in a wide range of research causes peculiar problems in coordination of aims. Research to identify, maintain, and enhance quality cannot be made the exclusive responsibility of a particular group of investigators. Rather, it must be carried on simultaneously in many, widely separated places. Each group has its own approach, and each must devise or adapt criteria and methods suited to its own problems. Yet the aims of all of them must be tied together in a consistent pattern aimed ultimately at increasing the end-use value of the product. Likewise, the work of each must be supplemented by that of others, for there is no benefit from breeding improved inherent quality into a product only to have it lost through improper handling in the market, or through failure of the consumer to recognize and take advantage of it in use. Effective devices are needed to coordinate this wide range of activities in order to prevent working at cross purposes and to assure balanced progress on all fronts.

Economic as well as technical aspects of quality are important. Costs attach to efforts at quality improvement, and each improved practice must be subjected to the test whether the added return obtainable for the higher quality exceeds the added cost. Whether this will be true

depends, among other things, upon whether grade standards or other devices are available in the market to enable buyers and sellers to discriminate quality differences in products, and whether buying, selling, and pricing practices take due account of these differences. Economic research is needed to achieve this, and likewise to analyze potential market demands and preferences in order to find profitable, unexploited opportunities to supply particular qualities.

Recommended Changes in Present Program

While recognizing that much more research is needed on the technological side, economic problems relating to market identification of quality should be singled out for special emphasis. Better research support should be provided for operations of agencies administering official grade standards and inspection programs. Practical aids to consumers in identification of quality of products at retail also are particularly needed.

Expansion of research relating to maintenance and identification of quality should include greater emphasis in plant and animal breeding research upon genetics principles, and upon techniques for breeding, selection, and testing, as well as upon numerous specific improvements now receiving insufficient attention. Research to improve cultural practices should place greater emphasis upon the physiology of plant and animal response to environmental factors, and more fundamental studies of forest management problems as they relate to quality of products. Increased attention to quality aspects in research on harvesting equipment and practices should include studies of weather in relation to curing of forage crops and the seasoning and machining of lumber. In marketing operations, it should provide broader coverage of commodity problems of quality as well as more basic investigations of post-harvest physiology, pathology, and environmental response of products, and of problems of insect control and insecticidal residues. In home use, it should provide for more ample studies of suitability of various products for different end uses, as well as of home and institutional methods of handling, storing, cooking, and preserving foods, and care of textile products, in order to make fullest use of inherent qualities.

In all phases of research increased emphasis should be placed on problems of defining and identifying quality. The work should include surveys of quality discrimination and preferences of users of products, analyses of market price differentials for quality, methods and procedures for the conduct of sensory testing panels, and development of physical, chemical, and biological tests of product characteristics. Correlations are needed between these several approaches to quality identification and measurement. Particular emphasis is likewise recommended on developing practical aids to consumers in identification of quality of products as purchased at retail.

On the economics side, an expanded program of research is recommended on ways to bring about fuller recognition of quality factors in buying, selling, and pricing practices, and studies to evaluate quality improvement

practices in terms of net returns to farmers and forest owners. Likewise recommended is a systematic, commodity-by-commodity appraisal of opportunities to expand demand, both domestic and foreign, through improvement of quality and better adaptation of products to buyers' wants. These economics studies will require collection of more and better market statistics on prices in relation to quality.

It also is recommended that further steps be taken to improve research support of marketing service programs, to develop standards for grades, and to solve problems of grading and inspection according to these standards.

While there now appears to be no serious problems of conflict in approaches to quality in different phases of research currently under way, it is clear that coordination will become an increasing problem in an expanding research program in this area. It therefore is recommended that workers in different aspects of quality be brought together to develop effective devices for assuring continuing contacts with one another for pooling of problems, assuring consistency of aims, and facilitating mutual supplementation of efforts.

Objective 11--New or Improved Uses and Markets

Research Program Needed

The development of new and improved uses and market outlets for farm and forest products has assumed extreme importance during the past few years because of the ever-mounting surpluses in important farm commodities. The problems confronting producers of these farm products were highlighted in 1956 when a bill was introduced in Congress "to provide for a scientific study and research program for the purpose of developing increased and additional industrial uses of agricultural products." In this bill it is stated that "current productivity of farms in the United States is substantially in excess of current markets for their products at price levels which provide fair and substantial income to farmers." In the hearings on this bill the U. S. Department of Agriculture stated that "to solve the surplus problem we must expand markets. We have three possibilities for doing this: (1) Stretch the export market as far as we can, (2) increase per capita consumption of higher quality foods, and (3) devise new uses for established crops and develop new crops with good market potentials as alternatives to those in surplus. We must use all three."

Congress also provided in Section 209 of the Soil Bank Act for the establishment of a Commission on Increased Industrial Use of Agricultural Products to study the problem and recommend to the Congress actions which will bring about the greatest practical use for industrial purposes of agricultural products not needed for human or animal consumption.

These facts have been taken into consideration in recommendations for substantial increases in the research to develop new and improved uses for farm and forest products with particular emphasis on commodities currently in surplus.

To a large extent, increases in food consumption in this country are proportional to increases in population. However, the producers, the processors, and the consumers of fruits and vegetables can benefit greatly from research aimed at the development of improved quality, stability, and convenience in processed products. Such development is based on potentialities revealed by exhaustive studies of the constituents and properties of products that can be exploited in new or improved products for the benefit of both consumer and producer. Because of the potential increased demand for livestock products and the consequent increase in numbers, there is a definite possibility of increasing feed uses for cereal and forage crops and oilseed meals.

The market outlets for cotton and wool are being narrowed by the ever increasing competition of man-made fibers. Prior to the advent of synthetic fibers, cotton accounted for about 85 percent of the entire United States consumption of fibers, whereas at present it accounts for only about 65 percent of the total. Greatly expanded research on cotton and wool is needed to improve their processing characteristics and to give them added qualities which will enable them to compete successfully with man-made fibers.

Maximum emphasis should also be placed upon the expansion of research to convert farm crops that are now being used primarily for food into products suitable for use by industry. Increased emphasis should also be given to economic and laboratory research to determine the industrial possibilities of new crops.

A major forest problem on farms and other forest holdings is the large volume of cull trees and little-used species for which there are inadequate or no market outlets. The problem occurs in all regions of the United States and is particularly serious in the vast hardwood areas of the East. The development of new or improved uses for this surplus poor timber would not only provide markets to producers but would permit its removal from the land where it increasingly occupies growing space that could be used to better advantage for the establishment of new and better crops of timber trees. Also, a tremendous volume of logging and primary manufacturing residues, as well as pulp plant residues such as lignin, remain unutilized except for fuel. Research in this area should be directed toward the development of processes where large bulks of raw material will be required.

Research in the laboratory and pilot plant to develop new and improved uses for farm and forest products must be supplemented by studies of price-quality relationships and the possibilities for enhancing market potentials through product improvements. The determination of the economics of new products, including measures of acceptability and economic feasibility, can assist in large measure in the commercial adoption of these products. Portions of the research programs described under many other objectives contribute to Objective 11.

Recommended Changes in Present Program

When Congress in 1938 authorized the construction of four regional laboratories to do utilization research on farm products, it also authorized a nationwide survey by competent scientists to obtain information upon which to base a comprehensive research program. The resulting program has been gradually expanded during the intervening years. Similarly, the Forest Products Research Laboratory has developed a well rounded program of research that includes such items as chemical wood; poles, piles, and tie timber; pulpwood; saw timber; and veneer timber. However, there are so many needs and unexplored opportunities for improving uses and serviceability of farm and forest products generally that a considerable expansion of the research in this field is called for.

Much too little attention has been given to the economic aspects of utilization. It is not enough to find methods of producing new kinds of goods. They must be produced at reasonable cost. And they must be able to meet competition from other products already on the market. This calls for increased emphasis upon economic research, both as a guide in product development and in analyzing and testing markets for products as they are developed.

The following changes in the present program are recommended:

Farm Products

Because of the serious surplus situation in cereal grains, research on these commodities should be expanded very substantially with emphasis on the development of food and feed products with higher nutritive value, and industrial products through chemical, physical, and microbiological transformations.

In order to provide suitable feed supplies for the increasing number of livestock, the research to improve and preserve the nutritive value of forage crops during processing and storage should be expanded substantially.

Because of current and potential future surpluses of vegetable oilseeds and animal fats, research should be substantially expanded to find new industrial uses for products obtained from the animal fats and vegetable oils, and improved feed uses for the oilseed meals.

In order to increase the consumption of dairy products, research should be expanded substantially to develop a readily dispersible dried whole milk, to obtain information on the structure of milk components and the changes that take place during processing and storage, and to develop improved types of cheese.

Research should be expanded on the production of improved poultry products, with special attention to the retention of flavor, and on the production of dehydrated whole egg that can be reconstituted more easily. Research should be initiated to develop improved defeathering, chilling, and freezing methods for poultry.

Research on quality preservation and on the development of new meat products should be substantially expanded with special emphasis on improving the tenderness and palatability of low-grade beef; and on the development of new methods of processing hides to obtain new and improved products.

Because of the need to develop cheaper and more attractive processed forms of fruits and vegetables, research to develop stable and concentrated products that do not need expensive packaging should be expanded.

Research to develop better methods of processing sugarcane and sugar beets should be expanded and work to develop industrial uses for chemical derivatives of sugar should be initiated.

To meet the increasing competition of synthetic fibers, research should be expanded very substantially on the basic fiber properties of cotton and wool and on the mechanical and chemical processing of these fibers to obtain products of higher quality with greater consumer appeal.

Forest Products.--Research should be expanded substantially to find market outlets for inferior hardwood growth, cull trees, and unused residues from logging and milling, with particular attention to the production of industrial chemicals from lignin; to producing new types of composite glued products from wood and wood-base materials; and to developing improved adhesives, preservatives, and fire-retardants for wood, improved methods and fasteners for the structural use of wood, improved paper and resin-impregnated paper structural units, and better containers for industrial and agricultural products.

Domestic Market Research.--Research should be expanded to provide more intensive analyses and wider coverage of commodities, with emphasis on market testing and development; evaluations of advertising and promotional activities; inter-product competition and market potentials; consumer discrimination and preferences as they relate to new and improved products; and the economics of the utilization of new and improved products.

Foreign Market Research.--Research with particular emphasis upon analyses of foreign government programs on production and trade should be expanded; also on trade agreement programs and United States programs to promote sale of farm products abroad; responses of foreign production and consumption to changing prices in world markets for various commodities; preferences of foreign buyers; and means for meeting competition from foreign-produced commodities and obtaining greater access to foreign markets.

New Crops.--Research to determine specific immediate and long-range new-crop requirements should be expanded with particular attention to those crops which might be grown in place of crops now in surplus; to evaluate and screen plant introductions and maintain germplasm; to develop industrial uses for products derived from new crops, with special attention to studies of the market potentialities and the anticipated costs and returns for the products derived from the new crops.

New Types of Animals.--Research to develop improved types of animals should be expanded, with special attention to their adaptability to geographic areas and to various types of feed and forage; to explore the possibility of increasing the value of milking cows as meat sources; to develop improved meat-type hogs; and to develop methods for evaluating the meat and wool qualities of sheep on the hoof.

Objective 12--Higher Levels of Living

Research Program Needed

Any research directed toward improving the economic position of families is of great importance for improving family levels of living. Also important is the use made by families of their money, time, and other available resources, including public and community services. Management decisions as to the use of resources are closely related to the extent that people can achieve goals or standards of living.

Management problems of the farm home and the farm business have always been closely intertwined, but new problems arise as rural life becomes increasingly urbanized, farming more highly commercialized, and new opportunities are afforded for part-time employment off the farm.

New kinds of decisions must now be made as to use of time--its allocation between farm and off-farm employment or work outside the home, and between money-earning activities and those related to household production of goods and services for family use. New considerations are involved in the division of limited money incomes between expenses for the farm business, getting ahead financially, and expenses for living. New problems in judging values emerge as science and technology put new goods and services on the market. New media of communication have created new wants, complicating the problem of achieving balance among expenditures for various needs and wants of family members, including use of public or community facilities. Research relating to house design and construction, and progress in rural electrification will make it possible for new and remodeled houses to be made more functional, livable, and efficient.

Developments such as these mean that family management decisions are more involved than ever before. Families require broad technical and economic knowledge if their decisions are to enable them to make the most of modern opportunities for higher levels of living.

Educational and other programs to facilitate decision-making for better living should have a broad research base. They require research that depicts current levels of living, such as are reflected in quantities of different goods and services used in living, in the character of housing, in the extent of use of contributing public or institutionalized services, and in current practices in the use or management of these goods and services. These programs also should take into account the extent to

which living levels of groups of families meet given standards, changes that are taking place over time and differences among communities, and the extent of improvement that follows income increases or as there are changes in practices of management or use of resources.

Research also is needed to provide the knowledge that consumers require to evaluate various goods and services, so they may choose those best suited to meet the purposes for which intended; to develop improved methods of carrying on household tasks such as preparation and preservation of food, care and maintenance of family possessions, and care and training of children.

In addition, research is needed to provide plans and working drawings for economical and functional housing; to appraise facilities for, and operation and organization of, institutional arrangements for services of various kinds; and to discover how to motivate people to make use of new knowledge, to be interested in acquiring new skills, and to make effective use of such cooperative, public, and institutionalized services as can supplement private efforts for achieving better living.

Recommended Changes in Present Program

Research concerning family living and rural life is on a very small scale, and all segments of such research should be greatly expanded to provide the basis for better educational and action programs. Particularly needed is more adequate and more continuous information on the situation with respect to levels of living and more facts and principles for decision-making and improved management of resources by families. Research to promote improved housing and rural facilities for education, health, credit, risk-protection and old-age security should also be substantially expanded.

Large-scale surveys should be undertaken at least every 10 years to provide simultaneous data on expenditures for living and consumption of farm, rural nonfarm, and urban groups (in association with the U. S. Department of Labor), with smaller scale or regional surveys in intervening years for analysis of special problems. Work should be extended to appraise the significance of the resulting data to educational, farm, and other programs, to develop more valid indicators or indexes of living levels attained, as standards change, for farm and other groups, and to provide statistical data on financial status of farm families, including the impact of social security programs, by areas and type of farm and family situation.

Greatly expanded should be the type of research that will facilitate consumer evaluation of qualities of food, clothing, household furnishings, and equipment for specific end uses; the development of improved methods and procedures for home preparation and preservation of food; revision of guides to food selection and meal planning as nutritional knowledge advances, as new products appear on the market, and as economic conditions change; and improved procedures for care of modern fabrics. Also expanded should be research to provide data useful to families in long-range financial management, such as information on how family living costs change with the rearing and education of children and as children grow up and leave the

home; the comparative time and money costs of buying or producing goods and services at home for household use; replacement rates of durable goods; costs of risk-protection and credit.

Research that will provide families, builders, and architects with information needed to improve rural housing should be accelerated, especially work to determine minimum structural requirements of houses, and desirable dimensions and arrangements of space, equipment, storage facilities; requirements for environmental comfort, such as temperature, humidity, and air movement; requirements for electrical power, for water, and for methods and equipment for economical sewage disposal. More research also is needed relating to materials for building and for interior finishes, to methods of protecting them against deterioration, and to improved and cost-saving methods of installation; performance requirements and replacement rates for heating, refrigerating, and labor-saving equipment. The integration of results of segments of housing research into working plans and drawings should be accelerated. These plans should then be tested for suitability for different types of farming, regional, and environmental situations.

Because conservation of human resources is of such great importance to the Nation, and because agriculture can make unique contributions to this, more attention should be given in all agricultural research to these aspects of protection of human life and the provision of improved environment for living. For example, in view of the importance of nutrition to buoyant health at all ages, research should be initiated on methods of motivating persons to make use of nutritional knowledge as it develops, and on evaluating the effectiveness of various types of educational programs and to develop good food habits. In research to improve buildings, farm machinery, household equipment, and work clothing for family or farm use, more consideration should be given to features making for personal safety in their use and minimizing opportunities for accidents--especially in view of the extensive participation of rural children in home and farm operations. In research on housing, attention should be paid to space and facilities needed for social recreation, rest, and privacy, as well as to efficient arrangement and placement of space, equipment, and storage facilities for work activities. In research on the utilization of forest and nonagricultural lands, more attention should be given to the great need for outdoor recreation by children, youth and adults.

Research to promote better understanding of the organization and structure of essential rural institutions should be expanded and to explore, in association with appropriate agencies, how people may work together to bring about improved services and wider and wiser use of vital community resources. Community organizations, such as those for education, health, recreation, and communication are important to the welfare of families, and the economic life of people is affected by the use they make of credit, insurance, cooperation, and social security.

Objective 13--Organization of Farming and Forestry

Research Program Needed

During the last two decades producers of farm and forest products have experienced rapid changes in production conditions and wide fluctuations in the market for their commodities. Equally significant changes are likely to be in store for the decades ahead. New technology will bring changes in production, and demand for farm and forest products also will change. Moreover, we can expect modifications in farm programs and other economic institutions affecting farm people.

Producers will be required to adapt their operations to all these changes, and agricultural administrators will need to provide educational and program guidance that will facilitate adjustments to a more prosperous agriculture. To provide such guidance will require continuing analysis of changes and of ways of facilitating adaptation. It will be necessary to study on a continuing basis the types of organization of farming and forestry that are likely to provide the best prospects for progress, income improvement, and stability in different areas. This will involve determining: (1) the most efficient sizes of farm and forestry business units, (2) the most profitable systems of farming or forestry, and (3) the advantages or disadvantages of combining in the same business unit the functions of production, purchasing of supplies, and marketing of products (vertical integration). If owner-operatorship of productive family farms is to remain a major goal of farm people, special emphasis will be needed on the financial and other means for achievement of this goal, and on ways in which young people of suitable aptitudes can become established in farming.

Recommended Changes in Present Program

The research program which has special application to this objective has been so limited by available funds that coverage has been fragmentary and sporadic, both as to timing and geographic distribution. As a result, area studies have been undertaken in different time periods to help alleviate acute maladjustments. But scattered area studies conducted at different times cannot be fitted together to determine inter-area and national potentials. Continuing study is needed of all major farming areas to permit periodic analyses and summarization of farm, area, regional, and national results, for comparison with market potentials. Continuing studies of this type will provide basic data for many other purposes. They should include measures of current changes in farming that can be used as data for appraisal of emerging problems. Similar studies are needed for major forestry areas.

There are few current studies of the most efficient sizes of farm and forestry units, considering improved technology, cost-price relationships, tenure, and financial and other factors. And despite the rapid growth of different ways of tying in production with purchase of supplies and with marketing in broiler, egg and vegetable production, there are no studies of the effects of such combinations on efficiency

and income. The effects of such combinations on the competitive position of family farms should be analyzed; also, the effects of contracts with farmers for production and delivery of specified products, and of contracts for supplies and services. Alternative ways of securing needed combinations of functions, including greater emphasis on cooperatives, should be explored. (See also Objectives 4 and 14).

The following specific changes should be made in the research program to provide more adequate guidance in adapting farming to changes in markets, technology, and other factors:

Additional studies need to be undertaken to determine the most efficient sizes of farm and forest units in different regions, considering technology, tenure, and financial and other conditions (including economy of scale). The competitive position of efficient family-scale versus large-scale farms should be analyzed by farming areas; also, the potential effects of changing sizes of farms on family and hired workers, incomes of farm people, and efficiency of production.

Production adjustment and related studies should be expanded to complete and keep up to date the guidance needed for establishment and maintenance of efficient farm and forestry systems in farm and forest areas with broadly similar production opportunities. Costs and returns series should be combined with adjustment studies to provide measures of current changes in the same areas. Research on combinations of practices and the physical inputs and costs of these combinations should be strengthened. Farm trial research should be undertaken to appraise how new combinations of crops and livestock and of improved practices work out in practical farm operations. Research on cost of establishing, growing, and utilizing timber on various sites and of various forest types should be expanded.

Objective 14--Market Organization and Practices

Research Program Needed

The United States has developed an efficient, highly technological, specialized system of production of its basic agricultural necessities-- food, fiber, and forest products. The productivity of this system furnishes us a high level of consumption of these products, even though we devote to their production a smaller proportion of our working force than do most other countries.

The counterpart of our efficient and specialized production system in agriculture is an intricate, far-flung organization of markets through which farm products are traded in the successive operations of assembly, transportation, processing, storage, domestic distribution, and export. We depend upon daily trading in these markets to coordinate the continuous movement of supplies geographically and their seasonal flow into consumption. The prices established in these markets determine both how much final consumers pay for the products and how the consumers' payments are divided between producers and the various enterprises that participate in marketing. The welfare of farmers and forest owners and of the Nation as a whole depends just as vitally upon the effective performance of marketing functions as upon efficient production on the farm.

In the organization of markets, just as in the organization of production, national growth, changing patterns of consumption, technological progress, and structural developments in the economy create problems of maladjustment and open opportunities for improvements. The rise of truck transportation over the past quarter century, for example, has made possible much more direct movement of products from producing areas to points of consumption-- and this has been a factor in the diminished importance of large central markets as focal points in which prices are established for many commodities. Refrigeration in transportation, in food processing, and in the home has widened the market for perishables, extended their use seasonally, and created the opportunity for a whole new industry in frozen foods. Successful application of irradiation to the preservation of foods may conceivably in the future have equally far-reaching effects upon organization and practices.

Improvements in the organization of markets and in the conduct of trade in farm and forest products, and the detection and guidance of needed adjustments require research that provides basic understanding of how markets operate, establishes criteria for their effective performance under varied commodity situations, and anticipates new developments, their prospective impact, and the adjustments they will require.

A comprehensive research program to this end should systematically evaluate marketing systems and seek to improve them from the following standpoints:

- (1) Is the organization of markets conducive to the most efficient physical handling of products and performance of marketing operations?

(2) Does it establish a structure of prices that is equitable to producers, consumers, and intermediate agents, that channels current supplies into their most advantageous uses and makes the best geographic and seasonal distribution of them, and that guides future production in response to the wants and needs of consumers?

(3) Is it progressive in adapting promptly to changing conditions of production and consumption, and in adopting new and better practices?

Recommended Changes in Present Program

To measure up to this need, the present program of research in organization of markets for farm and forest products must be greatly expanded. The studies that have been made in this area have been directed too largely toward the immediate delineation and solution of fragmentary problems. In marketing even more than in other areas, the effort must be built up to the point where a margin of resources exists, over and above that required for narrowly problematic research, in order to build up a systematic body of knowledge, coordinating information and developing concepts basic to doing a progressively better job of anticipating needs and devising consistent and enduring ways of meeting them.

Problem areas requiring a substantial increase in effort include the effective organization of buying and selling, the functional aspects of prices and pricing, and the effects of legal and other institutional arrangements and of management practices underlying the process of exchange. Emphasis is needed on the geographic structure of markets, the effects of freight rates and other transfer costs upon market patterns, and problems of adjustment among competing producing areas.

Research to improve efficiency of physical operations in marketing is discussed under Objective 9; in addition to efficiency problems included there, however, increased attention is needed to over-all appraisal of efficiency in performance of whole marketing functions and of commodity marketing systems, with emphasis upon economics of scale and of location.

Problems arising from the changing structure of industry need particular study at this time, especially the merger movement and the consolidation of control of marketing activities through vertical and horizontal integration of functions. Where integrative developments reach back to impinge upon farm production itself--either through outright ownership, as in the purchase of orange groves by processors, or through contractual or credit arrangements as in canning crops or broiler production--the marketing research should be coordinated with that on the organization of farming, discussed under Objective 13.

Research on the procurement of farm production supplies and services, again related to that under Objective 13, should be greatly intensified with respect to the operations of farmers' purchasing and service cooperatives and initiated as to procurement through other channels. Research on cooperative marketing, likewise, needs substantial expansion so that

a more comprehensive job may be done of attacking the special problems faced by these organizations set up by farmers to serve their own marketing needs more effectively.

In foreign, trade, very little research is currently devoted to fundamental problems of market organization and practices. Substantial expansion of foreign trade research in this direction is needed to guide improvement of commercial operations and to provide a sounder basis for trade policies and programs.

Research to develop better organized markets and improved practices in pricing timber has been recent in development, and needs particular emphasis to bring it abreast of that for other commodities.

Finally, research should be expanded and comprehensively systematized to bring together information on trends and developments in technology, in production, in consumption patterns, and in business structure, and to appraise their prospective impact upon agricultural marketing-- the problems they will pose and the opportunities they will offer for future improvement. Systematic research in this area could greatly increase the effectiveness of the whole research program through anticipatory guidance to other efforts.

One problem of policy, particularly bothersome in marketing research, arises from the controversial nature of work in which findings are likely to be seized upon by parties at interest to blame or extol rather than, in scientific spirit, to appraise objectively and seek to improve. This problem is inherent in any research which seeks to focus objective scrutiny upon activities in which substantial interests are at stake. The Committee is of the opinion that the research program should be bolder in its approach to such problems, recognizing, however, the increased obligations that this places both of thoroughness and rigorousness of analysis and of objectivity in interpreting and reporting research findings.

Objective 15--Agricultural Statistics

Research Program Needed

Ever since the Department was organized, it has been called upon to gather, analyze, and publish a wide variety of statistics. Over the years it has developed in cooperation with State agencies a broad and closely integrated service for carrying out this responsibility.

As the Country has grown, and as agricultural marketing has become more complex, the need for agricultural and forestry statistics has increased and the necessary scope has widened. Farms and forest operators, transporters, processors, distributors, consumers, administrators, and legislators constantly use and rely upon statistics concerning current and prospective production, stocks, prices at all stages of marketing, rates of consumption, foreign trade, farm population and employment, the financial position of farmers, and many other matters.

In addition to the gathering and publishing of raw statistics, a great deal of statistical analysis is required. In part, this analysis is to improve the accuracy of statistical estimates, and to interpret the meaning and significance of the data. And in part it is to improve the methods of research in all lines of agricultural science.

Although the statistical program is generally considered to be strong, it needs continuous attention and improvement. Our published statistics must be made as comprehensive, as accurate, and as timely as our budget permits. Our analytical methods need continuous improvement to take full advantage of more efficient techniques.

Recommended Changes in Present Program

Better coordination of published data is needed in some cases, including production, marketing, and stocks, farm employment, and foreign trade. The Committee recommends increasing attention to the improvement of the quality and accuracy of statistics in special fields, including prices received and paid by farmers; farm income, costs, and returns; land use; productivity; farm debt; balance sheet of agriculture; foreign trade; forest resources; and the production, end uses, and prices of forest products. Such improvements in the quality of statistics should have first priority in an expanded program.

The Committee recognizes, however, the need for filling important gaps. As funds permit, we need additional data on such matters as farm income and numbers of farms by type and economic class; production of pastures and of grass silage; irrigated and non-irrigated land; summer fallow; and water-use inventory. More frequent reports are needed on production and prices of livestock and poultry and production of minor oilseeds, and more detailed breakdowns of production and stocks of dry beans and peas. More data are needed on use of fertilizer and feed; the financial condition of major groups of farmers; conservation programs; storage capacity; numbers and types of trucks handling farm products; production and use of cooking and salad oils

and of certain other food products; prices and quantities by quality grades; sales of cigarets by type; synthetic or derived materials used in foods; inventories and military takings of cotton, wool, and textile products; national-emergency needs; labor costs in processing and marketing.

The Committee further recommends consideration of an annual sample census of agriculture; establishment of national panels of farmers and of consumers; periodic surveys of family consumption of food and of other goods and services; surveys of food consumption in restaurants and institutions; surveys of individual diets; an intensive study of food marketing and consumption in one community; and research on prices, price making and price quotations in terminal markets.

Statistical Theory and Methods and their Application--The Committee recommends increased emphasis upon basic research in statistical theory and method as an integral part of the agricultural research program. It likewise recommends expansion of facilities for statistical consultation and the preparation of handbooks, guides, manuals, and similar aids to research and training.

*What about f.o.b. and general price
quotations by mkt. houses?*

Objective 16--Agricultural Policy and Programs

Research Program Needed

In recent years, the stabilization and conservation programs of Department of Agriculture have cost over \$1 billion a year (including net losses of the Commodity Credit Corporation). The public wants, and expects, to get full information on how this money is spent, on the economic effects of existing programs, and on the probable costs and effects of various alternative programs. There is a special need for information concerning the effects of programs designed to support farm prices and incomes; to adjust production; to step up domestic consumption; to increase exports; to divert surpluses; and to conserve soil, water, and forest resources. There is a less urgent, but important, need for information on the effects of regulatory and service programs.

Recommended Changes in Present Program

At present there is no systematic and comprehensive research on the economic effects of public programs and policies affecting agriculture. Instead, special quick studies are made sporadically by task forces at the request of the Congress or the Secretary of Agriculture. The Committee believes that the lack of adequate studies in this field is a major weakness of the research program.

The Committee recommends that an organized effort be made to work with the several action agencies and other groups in a continuous review and analysis of the effects of agricultural programs.

This recommendation is not intended in any way to reduce the responsibilities of action agencies for studying their own problems. Such work within the several action agencies needs to be strengthened.

Major attention must, of course, be given to the big, expensive programs, such as those dealing with price support, production adjustment, and the soil bank. The Committee recommends, however, that more attention be given to the effects of meat inspection, quarantines, marketing orders, and the regulation of packers and stockyards, upon such matters as farm income, nutrition, prices and the structure of marketing. It recommends more attention to farm credit, crop insurance, rural electrification, and the agricultural outlook reports.

The Committee further recommends increased attention to the study of inter-relations between agriculture and the rest of the economy, including the effects of general economic policies upon farmers and the effects of agricultural policies upon nonfarmers.

IV. Projected Public Expenditures for Agricultural Research

Research toward each of the research objectives is being conducted by Department and State agencies but the Committees regard the present program as inadequate in view of the importance of agriculture to the national welfare, and the gravity and complexity of agricultural problems.

Most of the Committees' recommendations suggest changes designed to establish a proper balance between the large segments of the agricultural research program, not through increasing the small by paring the seemingly large, but through raising appropriately the level of effort on each. The funds now devoted to public research are insufficient to balance the program and simultaneously make it possible to devote the attention needed to the myriad problems that demand research if agriculture is to receive additional help from this source commensurate with its needs and importance.

The Committees recommend that, over the next 10 years, annual public expenditures for research be increased about $3\frac{1}{2}$ fold. In addition, provision must be made for substantial expansion and modernization of research facilities. Together, these actions would represent a reasonable effort toward bringing the total agricultural research program into better balance with research undergirding the rest of the economy, and would enable the Department and State agencies to achieve better balance among the researches related to the various objectives.

For each of the 16 objectives discussed in previous sections, there are shown below the expenditures per year that the Committees recommend should be achieved by 1968. These figures are exclusive of expenditures for buildings and facilities.

	F. Y. 1968 (in \$1000's)
For research relating to:	
1. Consumer needs, wants, and preferences	\$ 20,000.
2. Inherent values of products	38,000.
3. Prospective demand and supply	13,000.
4. Overcoming obstacles to profitable adjustments	8,000.
5. Efficient structures and equipment	26,000.
6. Conservation of basic resources	80,000.
7. Hazards in production and marketing	113,000.
8. Protection in national emergency	4,000.
9. Efficiency in production, processing, and marketing	86,000.
10. Product quality	59,000.
11. New or improved uses and markets	106,000.
12. Higher levels of living	9,000.
13. Organization of farming and forestry	6,000.
14. Market organization and practices	13,000.
15. Agricultural statistics	12,000.
16. Agricultural policy and programs	<u>7,000.</u>
TOTAL	\$600,000.

The Committees consider that some areas of research need very substantial expansion because they now are supported less adequately than others in relation to need. Thus they recommend about an 8-fold expansion in expenditures for studies of consumer needs, wants, and preferences (Objective 1), but barely a 3-fold increase for research relating to hazards that interfere with efficient production and marketing of agricultural products (Objective 7). The importance attached to research in each area is also indicated, however, by the actual expenditures recommended for each area. Thus for research relating to Objective 1, the Committees recommend about \$20 million annually by 1968, whereas for research relating to Objective 7, the figure is \$113 million.

To develop profitable and new uses and market outlets for agricultural products (Objective 11), the Committees recommend annual expenditures for research amounting to \$107. million by 1968. This increase over current outlays takes cognizance of public concern for finding profitable markets for those commodities which agriculture can produce in great excess over demand, including markets as raw materials for industry. Direct research in this area is also strongly supported by, and also depends on, research directed toward each of the other 15 objectives for agriculture.

The timing for increasing research activity in support of each of the several specific objectives will require consideration year by year in light of public needs as expressed in broad national problems. Research in each area will involve participation by a number of research units, but balance in the program to accomplish these objectives for agriculture does not mean that increases would be evenly distributed among research units. It means rather that the production, processing, marketing, and consumption research performed by various units will be increasingly integrated, and that production and processing research will be increasingly oriented to market demand and consumer needs. This calls for relatively greater expansion in the research of some organizational units than others, depending both on the urgency of problems and on the adequacy of the current programs.

V. Factors Affecting Achievement of Research Expansion Goals

Personnel

An expansion in the agricultural research program of the magnitude visualized would require an additional 4300 professional personnel per year for 10 years to satisfy public and private needs. This number represents approximately 50% of the number of graduates now receiving doctors and masters degrees in pertinent fields each year. Since there is a large demand for personnel having this type of training in areas other than agriculture, it is unlikely that agricultural research institutions will be able to achieve the rate of expansion visualized until the rate of out-turn of graduates increases. This would mean that in moving toward achievement of the envisioned expansion goal it would be necessary to progress by smaller increments in earlier years and correspondingly larger increments in the later years to attain the projected level by 1968.

Steps need to be taken to increase the number of students registering for and graduating in the fields of science of interest to agriculture. The following considerations are pertinent.

The shortage of professional manpower is almost certain to continue for 10 to 15 years. We are now just beginning to feel the impact of the low birth rates of the 1930's and early 1940's. Few scientists (including those in social as well as physical and life sciences) are trained and ready for original research at ages below 25, so we are now ready to draw upon those born in 1930, '31, and '32. These are the years of precipitous drop in birth rate. And birth rates stayed low well into World War II. The soaring birth rates of the mid-1940's cannot provide relief until about 1970.

These overall shortages may be partially offset so far as scientists are concerned by the increasing proportion of the population attending college and by the growing participation of women in science. The need, therefore, is to influence an adequate number of college students to enter the agricultural sciences and the basic sciences upon which agriculture draws for its professional personnel.

Increasing longevity is another source of imbalance in the population that may contribute to the recruitment problem. An expanding economy in a population with a shortage of the more productive age groups, compared with the very young and the elderly, is almost certain to intensify competition for the more productive people. Competition for these people will be between research and other occupations as well as within research itself.

Competition in recruiting begins actually in the high schools where career ideas of students begin here to take form. The Department and the States should begin here to intensify and personalize their efforts to interest young people in careers in the sciences and in agriculture. Agricultural scientists should participate in science talent searches, for example, provide lecturers and exhibit material, and get agricultural sciences prominently into career counseling. Among undergraduates in colleges, the

recruiting efforts should be still further personalized. They should consist largely of interviews with students and teachers, and addresses to organized groups by scientists who can speak first hand and effectively of the opportunities and rewards of their scientific work. The presentation should be aimed at dispelling or overcoming the reported current antipathy toward a career in science on the one hand and toward governmental employment on the other. Research people in the field are strategically placed to do these jobs. They should be aided by a well-thought-out, realistic and organized program and should be impressed with the need to do their part well.

In the envisioned expanded research program there will be abundant opportunities for women trained in the sciences. Recruitment for them should be as intensive as for men.

The supply of scientists in other countries should be drawn upon to meet our expanding needs. This might be done through exchange of personnel on a temporary basis or through other arrangements. In addition, legislative authority to employ competent and acceptable aliens should be obtained. Still other avenues might be disclosed by careful study, and such a study is recommended.

General upward revision of salary scales for scientific and professional workers to levels competitive with those of industrial and other employers is essential. The need for such adjustment is general with almost every profession and field of science included. With the increasing competition in sight, delay of even two or three years in making the needed adjustment could retard progress over several years.

Delay in facing and solving these problems will, without question, jeopardize the success and productivity of the expanded research program recommended in this report. The kind of research contemplated cannot be accomplished with second-string scientists. The importance of agriculture in our economy demands that agriculture be in position to compete with all who draw upon the professional pool in attracting, training, and holding its share of the best.

Facilities

To implement the expanded program envisioned, expansion of facilities must necessarily accompany expansion of staff. An analysis of the space currently being used for agricultural research in the Department -- including laboratory, office, pilot plant, greenhouse, barn, and other accessory structures -- indicates that approximately 1,000 square feet of space is required per professional employee. Accordingly, provision of adequate space to house the expanded program will require the accession of approximately 4,300,000 square feet per year during the 10-year period, about 1/2 of which would need to be public construction. Needs for specific types of facilities and appropriate location for them will require consideration both on an over-all basis and on a year to year basis, depending upon the program segment to be expanded in any one year. Similar problems of providing adequate facilities will be encountered at each Experiment Station and their Sub-stations.

APPENDIX - NAMES OF TASK GROUP MEMBERS

This appendix lists the Chairmen and members of the task groups that worked with the Department's Committee on Research Evaluation in reviewing the research program of the Department. The task group studies were conducted in the period between May 1 and July 31, 1956, the majority being completed by July 1. On the average, the equivalent of some three weeks' full-time effort was devoted by each group to completing its review and preparing its report. Identification of agency abbreviations appears at the end of the list of members.

Abrahamsen, Martin A., FCS
 Allaway, W. H., SWC, ARS
 Allgyer, J. R., OA, ARS
 Allin, B. W., OA, AMS, Chairman
 Anderson, Olaf, FAS
 Ault, W. C., EURD, ARS
 Bailey, W. R., FE, ARS
 Bachman, K. L., FE, ARS, Chairman
 Barker, H. D., CR, ARS
 Barnes, C. P., OA, ARS, Chairman
 Barton, Glenn T., FE, ARS
 Batchelder, E. L., HN, ARS
 Bayley, N. D., AH, ARS
 Beal, J. A., FIR, FS
 Beard, D. F., CR, ARS
 Beavens, E. A., WURD, ARS, Chairman
 Bell, G. D., FAS
 Boswell, V. R., CR, ARS
 Brant, A. W., AH, ARS
 Breimyer, H. F., AEC, AMS, Chairman
 Brew, M. L., HHE, ARS, Chairman
 Brewster, J. M., MOC, AMS
 Bruce, W. M., AE, ARS
 Burks, G. F., C, FS
 Byrne, J. J., FPR, FS
 Callander, Ronald C., CEA
 Campbell, L. E., AE, ARS
 Christensen, R. P., FE, ARS
 Coons, C. M., HN, ARS
 Cooper, M. R., MOC, AMS
 Crickman, C. W., FE, ARS
 Crooks, D. M., CR, ARS, Chairman
 Crow, William C., TF, AMS, Chairman
 Dachtler, W. C., MOC, AMS
 Daly, Rex F., AEC, AMS
 Davis, H., FD, AMS
 Davis, R. E., AH, ARS
 Dawson, E., HN, ARS
 DeFelice, R. A., TP, FAS
 Denton, C. A., AH, ARS
 Dice, George A., SSD, AMS

Dodge, J. R., AE, ARS
 Dupre, Mason, SURD, ARS
 Engberg, R. C., FCA
 Engelman, Gerald, MOC, AMS
 Erlanson, C. O., CR, ARS
 Eskew, R. K., EURD, ARS
 Evans, C. F., SWC, ARS
 Eyre, F. H., FMR, FS
 Finner, Winn F., MOC, AMS, Chairman
 Fleischer, H. O., FPR, FS
 Foote, R. J., AEC, AMS
 Fracker, S. B., OA, ARS, Chairman
 Gessner, Anne L., MS, FCS
 Gershben, Sidney, AEC, AMS
 Gilliland, C. B., MOC, AMS
 Goodsell, W. D., FE, ARS
 Graumann, H. O., CR, ARS
 Haeuseler, G. J., Ent, ARS
 Hagood, M. J., AEC, AMS
 Harding, P., BS, AMS
 Heinton, T. E., AE, ARS
 Heisig, C. P., FE, ARS
 Hiner, R. L., AH, ARS
 Hobbs, Harold, SWC, ARS
 Hoffmann, C. H., Ent, ARS
 Holland, Irving, FER, FS
 Holt, Budd A., TF, AMS
 Hopp, Henry, TS, FAS
 Houseman, E. E., OA, AMS, Chairman
 Hulburt, W. C., AE, ARS
 Hurst, W. M., AE, ARS
 Inman, B. T., FE, ARS
 Johnson, H. W., CR, ARS
 Johnson, Neil W., CPO, ARS, Chairman
 Josephson, H. R., FER, FS
 Joy, Barnard, OA, ARS, Chairman
 Keller, Wesley, CR, ARS
 Kelley, O. J., SWC, ARS
 King, David, FER, FS
 Koffsky, N. M., AEC, AMS

Langsford, E. L., FE, ARS, Chairman	Reitz, L. P., CR, ARS, Chairman
LeClerg, E. L., OA, ARS	Rettie, J. E., FER, FS
Lexen, B. R., FMR, FS	Rist, C. E., NURD, ARS
Lindquist, A. W., ENT, ARS	Rodenhiser, H. A., CR, ARS, Chairman
Liska, J. A. FPR, FS	Samuels, J. Kenneth, FCS
Lowenstein, F., AEC, AMS	Schwartz, Benjamin, ADP, ARS
Magness, J. R., CR, ARS	Scoville, O. J., FE, ARS
Mann, L. B., FCS	Shepherd, W. O., RMR, FS
Marston, H. W., OA, ARS	Sherr, H., AEC, AMS
McCallister, K. J., MOC, AMS	Sidwell, A. P., BSB, AMS
McKibben, E. G., AE, ARS	Simpson, J., WURD, ARS
McNally, E. H., AH, ARS	Smith, R. K., Ag.Est., AMS
Miller, H. F., Jr., AE, ARS	Steele, H. A., FE, ARS
Miller, M. E., MD, AMS	Stevens, H., EURD, ARS
Moore, L. A. AH, ARS	Stevenson, R. E., OA, ARS
Motheral, J., FE, ARS	Storey, H. C., WMR, FS
Mott, L. O., ADP, ARS	Sulzbacher, J., EURD, ARS
Murray, J., HHE, ARS	Sykes, J. F., AH, ARS
Naghski, J., EURD, ARS	Terrill, C. E., AH, ARS
Nauheim, C. W., FE, ARS	Todd, F. A., OA, ARS, Chairman
Nelson, L. B., SWC, ARS	Tysdal, H. M., CR, ARS
Oldham, H. G., HN, ARS	Uhland, R. E., SWC, ARS
Osborne, J. G., R, FS	Upchurch, M. L., FE, ARS, Chairman
Paramore, L. R. FM, FAS	Wadleigh, C. H., SWC, ARS
Parsons, M. S., FE, ARS	Wall, Norman, FE, ARS
Pentzer, W. T., BS, AMS	Walsh, R. M., MD, AMS
Phipard, E., HHE, ARS	Weiss, G. S., HHE, ARS, Chairman
Post, R. E., AEC, AMS	Wells, P. A., EURD, ARS, Chairman
Pultz, L. M., CR, ARS	Winters, Robert K., FER, FS
Purves, Clarence M., FAAD, FAS	Woolrich, A., CH, ARS
Rainey, W., SWC, ARS	Wright, J. W., COT, AMS
Rainwater, C. F., ENT, ARS	Zeller, J. H., AH, ARS
Randall, C. K., AEC, AMS	
Randell, C. G., FCS	

The following symbols are used to identify research units in the Agricultural Research Service (ARS), Agricultural Marketing Service (AMS), Forest Service (FS), Farmer Cooperative Service (FCS), Foreign Agricultural Service (FAS), and other organizational units referred to in the analysis summaries:

ADP - Animal Disease and Parasite Research Division, ARS
AE - Agricultural Engineering Research Division, ARS
AEC - Agricultural Economics Division, AMS
Ag.Est. - Agricultural Estimates Division, AMS
AH - Animal Husbandry Research Division, ARS
AMS - Agricultural Marketing Service
ARS - Agricultural Research Service
BS - Biological Sciences Branch, AMS
CH - Clothing and Housing Research Division, ARS
CR - Crops Research Division, ARS
CSS - Commodity Stabilization Service

ENT - Entomology Research Division, ARS
EURD - Eastern Utilization Research and Development Division, ARS
FAS - Foreign Agricultural Service
FCS - Farmer Cooperative Service
FDR - Forest Disease Research Division, FS
FE - Farm Economics Research Division, ARS
FER - Forest Economics Research Division, FS
FES - Federal Extension Service
FFR - Forest Fire Research Division, FS
FI - Farm Income Branch, AMS
FIR - Forest Insect Research Division, FS
FMR - Forest Management Research Division, FS
FP - Farm Population Branch, AMS
FPR - Forest Products Research Division, FS
FS - Forest Service
HHE - Household Economics, ARS
HN - Human Nutrition, ARS
MD - Market Development Branch, AMS
NURD - Northern Utilization Research and Development Division, ARS
OA - Office of the Administrator, ARS & AMS
OC - Market Organization and Costs Branch, AMS
RMR - Range Management Research Division, FS
R - Research, FS
SCS - Soil Conservation Service
SR - Statistical and Historical Research Branch, AMS
SURD - Southern Utilization Research and Development Division, ARS
SWC - Soil and Water Conservation Research Division, ARS
TF - Transportation and Facilities Branch, AMS
WMR - Watershed Management Research Division, FS
WURD - Western Utilization Research and Development Division, ARS



